NEW SOUTH WALES.

DEPARTMENT OF MINES.

GEOLOGICAL SURVEY.

L. F. PITTMAN, A.R.S.M., Government Geologist.

MINERAL RESOURCES
No. 18.

THE CANBELEGO, BUDGERY, AND BUDGERYGAR MINES.

PART II

OF THE

COBAR COPPER AND GOLD-FIELD.

BY

E. C. ANDREWS, B.A., F.G.S.,
GEOLOGICAL SURVEYOR.

1913.

SYDNEY: W. A. GULLICK, GOVERNMENT PRINTER.

1915.
[7s. 6d.]

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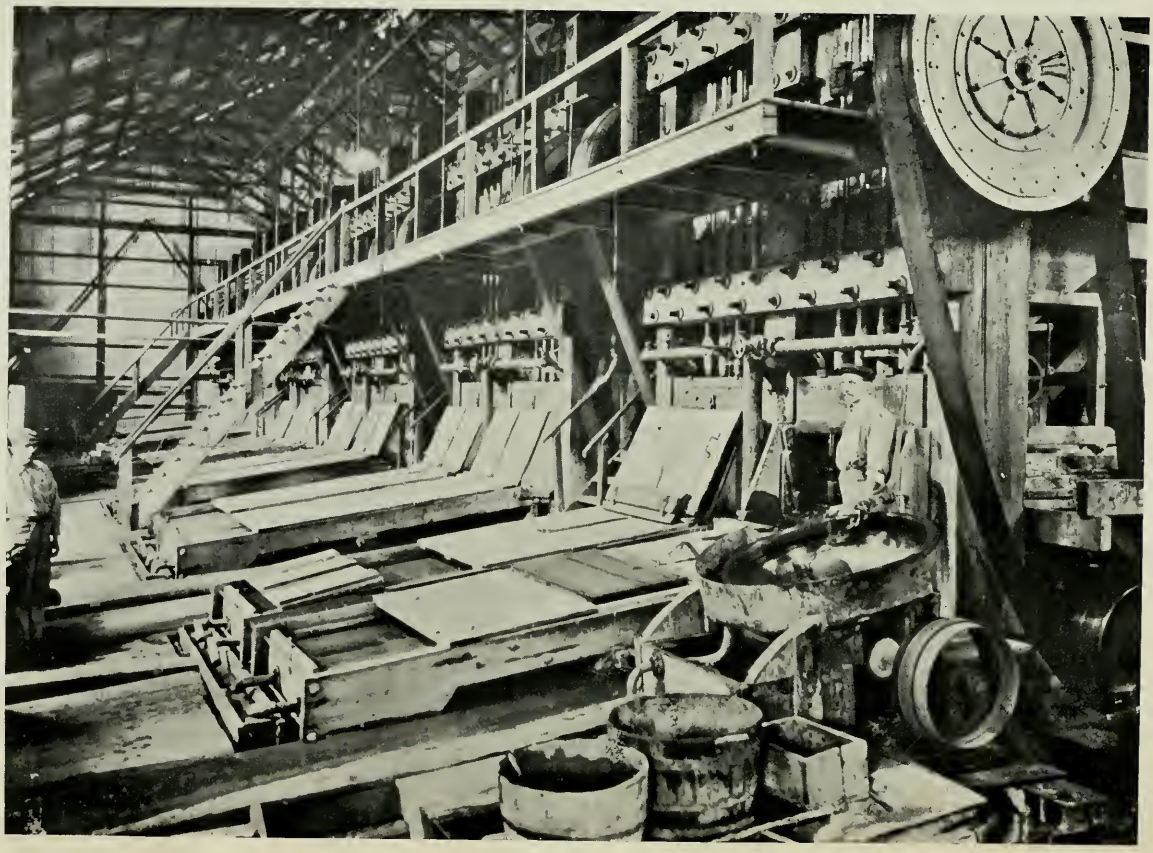

Battery, Mount Boppy Gold Mine

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LETTER OF TRANSMITTAL.

Department of Mines,
Sydney, 5th February, 1915.

Sir,

I have the honor to submit for publication a brochure (No. 18 of the Mineral Resources Series) on "The Canbelego, Budgery, and Budgerygar Mines," by Mr. E. C. Andrews, B.A., F.G.S., Geological Surveyor. This little volume really forms Part II of Mr. Andrews' work on "The Cobar Copper and Gold Field," and it contains descriptions of what may be termed the outside mines, including the celebrated Mount Boppy, which has for some years been the most productive gold-mine in the State.

I have the honor to be,
Sir,
Your obedient Servant,
EDWARD F. PITTMAN,
Government Geologist.

The Hon. J. H. Cann, M.L.A.,
Minister for Mines.

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... ...
... ..

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Map of New South Wales, showing the position of Canbelego.

IN POCKET AT BACK OF REPORT.

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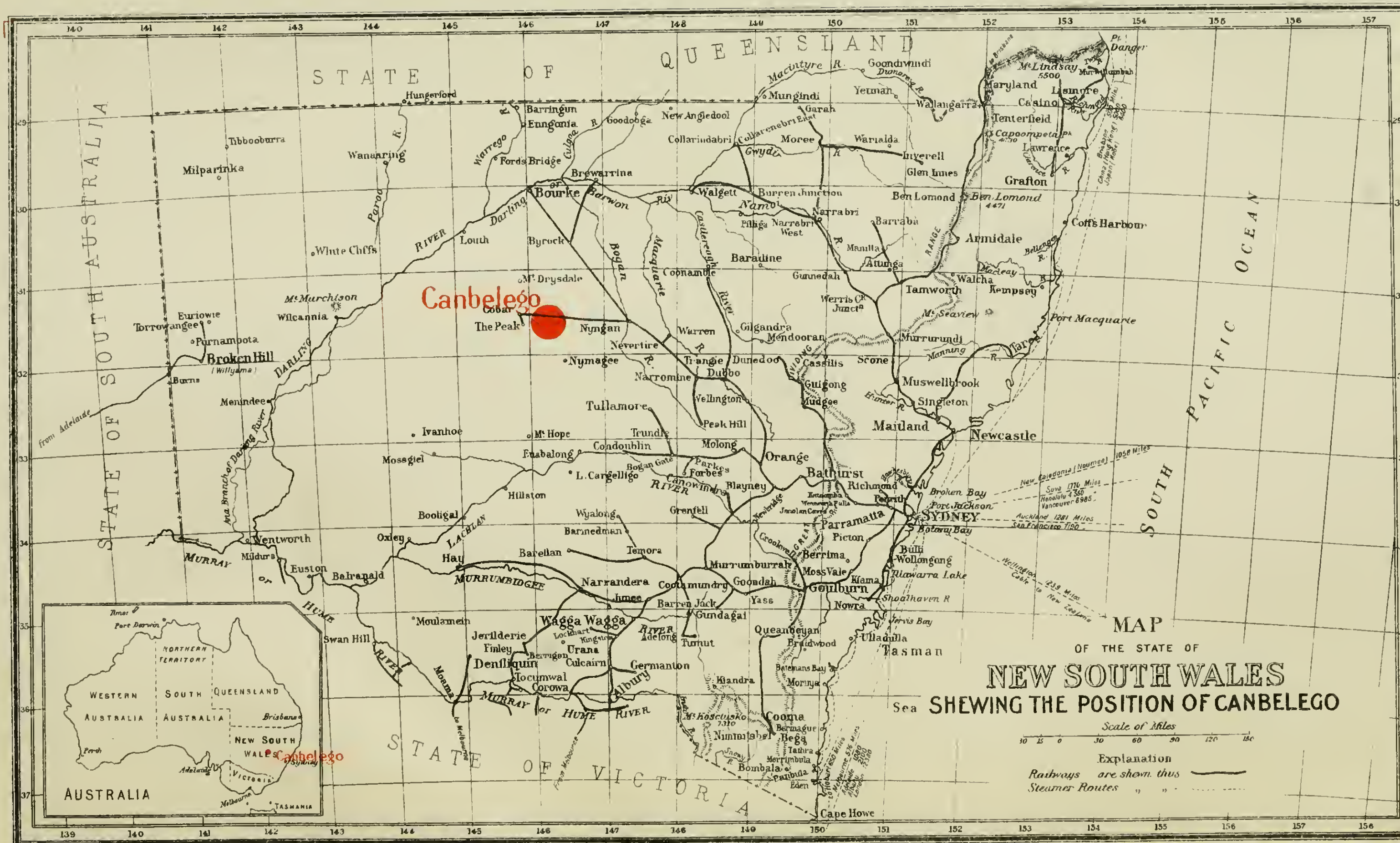
MAP
OF THE STATE OF
NEW SOUTH WALES
SHEWING THE POSITION OF CANBELEGO
Scale of Miles
Explanation
Railways are shewn thus
Steamer Routes " "
Canbelego
STATE OF QUEENSLAND
STATE OF SOUTH AUSTRALIA
STATE OF VICTORIA
SOUTH PACIFIC OCEAN
Tasman Sea
SYDNEY
Newcastle
Bathurst
Orange
Goulburn
Broken Hill
Bourke
Cobar
The Peak
Nyngan
Dubbo
Wagga Wagga
Albury
AUSTRALIA
Western Australia
South Australia
Queensland
New South Wales
Victoria
Tasmania
Lithographed & Printed at the Department of Lands Sydney, New South Wales 1914

INTRODUCTION.

In 1912 the writer was instructed to conduct a geological survey of the Canbelego Gold and Copper Field by Mr. E. F. Pittman, A.R.S.M., Under Secretary and Government Geologist to the Department of Mines.

Acknowledgments.

Special attention is drawn to the great obligation under which the writer is due to Mr. James Negus, General Manager of the Mount Boppy Gold-mining Company, Limited, during the preparation of the present report. Every facility was extended to the writer by Mr. Negus in the matter of examining the various mines under his supervision and permission to reproduce plans and sections of the mines was given without reserve. The majority of photographic illustrations in the report have been reproduced also from negatives lent by Mr. Negus. To Mr. John Polkinghorne, Underground Manager of Mount Boppy Mine, special thanks also are due for showing the writer many interesting geological features in and about the mine workings. The writer desires also to express his gratitude to Mr. Thomas Reid, of Canbelego, for showing him numerous localities of geological interest in the district, and for furnishing notes from which, in great measure, the chapter on the history of the district has been compiled. To Mr. A. W. Jones (Assayer), Mr. C. P. Flockhart (Surveyor), and the late Mr. W. D. Williamson (Metallurgist), members of the staff of the Mount Boppy Mine, the writer is indebted also for general information regarding the Mount Boppy field.

The writer desires also to cordially thank Mr. G. W. Card, A.R.S.M., Curator of the Mining Museum, for the preparation of the chapter on the petrology of the Canbelego rock types.

Attention should also be directed to the careful mineral and rock analyses accompanying the report, which were carried out at the Departmental Laboratory by Mr. J. C. H. Mingaye, F.I.C., F.C.S., and by Messrs. H. P. White, F.C.S., W. A. Greig, and W. G. Stone, under the supervision of Mr. Mingaye.

The standard maps of the Lands and Mines Departments have been used as the basis of the geological maps accompanying the report, and these geological maps, as also the mine plants, sections, and line figures, have been compiled by Mr. O. Trickett, L.S., Draftsman to the Geological Survey.

The photographic illustrations were prepared by the Government Printer, Mr. W. A. Gullick.

The reports of Messrs. J. R. Godfrey, David Milne, John Polkinghorne, R. Schloesser, and T. S. Oldfield, Government Inspectors of Mines, have been freely used in the preparation of the report.

Chapter I.

History and General Remarks.

Methods of Communication.

Canbelego lies to the north-west of Sydney. Communication between the two towns is established by railway and coach—438 miles rail and 3½ miles coach. The railway continues to Cobar, 26 miles farther west. The time occupied in the railway journey direct from Sydney is eighteen hours.

Climate and Vegetation.

The main features dealing with the climate and vegetation of this area have already been supplied in pages 11 to 13 of "The Cobar Copper and Gold Field," being Part I of this series. Canbelego is 26 miles east of Cobar and is 200 feet higher. On that account the climate is slightly cooler than at the larger town. The figures for Cobar may, however, be taken as practically the same as for Canbelego, namely, a maximum temperature of 118·70 degrees Fahrenheit (shade reading), and a minimum of 25·00 degrees during the years 1889 and 1882 respectively. The maximum recorded rainfall was 31·48 inches and the minimum (1902) of 5·29 inches, the average being about 15 inches for a record of thirty years, as taken by Mr. John Leah, of Cobar.

Dust storms are neither so frequent nor so severe as in Cobar. This is due, in great measure, to the fact that the native vegetation at Canbelego has not been destroyed to the same extent as in the neighbourhood of the more western town.

Vegetation.

The territorial fence, or boundary, between the Western and Central Land Divisions of the State, runs alongside of Canbelego, and the vegetation appears to vary considerably on both sides of the fence. Thus the well-known fodder plant of the west, namely, the mulga, is rare at Canbelego, whereas it is quite common at Cobar. The umbrella mulga is unknown at Canbelego, while rosebush is scarce and currawongs are not plentiful. The kurrajong has been destroyed in great measure. The black or red pine is abundantly represented in the young stage, but the mature trees have been cut out for miles around Canbelego, both for mining and household purposes.

Bimble box and coolabah exist in abundance, and are used for mining work, but the coolabah has a tendency to break short whereas the box timber is hard and interlocked.

The drooping form of oak (*Casuarina stricta*) occurs on the porphyry ridges, but the belah (*Casuarina Cambagei*) is almost unknown at Canbelego. The budtha (*Eremophila Mitchelli*), the tea plant (*Eremophila latifolia*), the turpentine (*Eremophila Sturtii*) represent the Eremophilas, but other members of this beautiful group, such as the wild fuchsias and

emu bushes (*E. oppositifolia, E. longifolia, E. Brownii,* and *E. Latrobei*) were not seen by the writer in the vicinity of Mount Boppy, nevertheless they are common in the Cobar area. Only one bush of the wild verbena (*Prostanthera striatiflora*) was seen within a radius of 10 miles. The native heath (*Eriostemon difformis*) is not uncommon, but neither *Petalostyles Labichioides* with its broad and golden flower disks nor the quaint *Prostanthera Leichhardtii* were seen. On the other hand, the "wattle" of the west, *Acacia decora,* is very plentiful on the lower slopes of the porphyry, schist, and quartzite hills. The whipstick mallee (*Eucalyptus viridis*) and the Brown mallee (*Eucalyptus Morrisii*) flourish on both the rocky ridges of the schists and the Devonian quartzites. Leopard wood (*Flindersia maculosa*) and beef-wood (*Grevillea striata*) are unknown at Canbelego, but are common at Cobar. Needle wood (*Hakea leucoptera*), *Pittosporum phillyræoides,* and the quandong (*Fusanus acuminatus*) are not common. On the other hand, the warrior bush (*Apophyllum anomalum*), the Cassias, the wilga, the sifting bush, the wild orange, and the wild lemon are all plentiful. Pin bushes (*Acacia cyperophyylla* and *A. colletioides*) are present also.

For a more general account of these plants the reader is referred to Part I, page 12, of this Cobar series.

Literature.

The subjoined list embraces the more important publications and references dealing with mining at Canbelego.

Jaquet, J. B.—Annual report, 1905, pp. 69-70, with plans and sections. Mr. Jaquet describes the occurrence of the Mount Boppy Lode as an inverted saddle.

"Geological notes upon the Structure of the Mount Boppy Reef." Records, Geological Survey of New South Wales. Vol. VIII, pp. 179-182, with plans and sections.

Carne, J. E.—Copper-mining Industry. 1908 edition.
Mount Boppy Copper Mine—pp. 248-250.
Canbelego Copper Mine—pp. 196-197.
Buppe Copper Lode—p. 196.
Conbelego Peak—pp. 197-198.
Canbelego West—p. 197.
Canbelego Queen—p. 197.
Canbelego North—p. 197.
Bergin's Lease—p. 197.
Shango Lode—p. 197.
North Shango Lode—p. 197.
Restdown Copper Lode—p. 196.

Milne, David.—Annual Report, 1897, p. 93; 1898, p. 100; and 1899, p. 98.

Godfrey, J. R.—Annual Report, 1900, p. 103. Also communications in writing concerning the Budgery Mine.

Schloesser, R.—Annual Report, 1902, p. 79.

Polkinghorne, John.—Annual Report, 1904, p. 89; 1905, p. 80; 1906, p. 94; 1907, p. 90; 1908, p. 95; 1909, p. 107; 1910, p. 96; 1911, p. 89.

Oldfield, T. S.—Annual Report, 1912, pp. 93-97; 1913, pp. 101-109.

Some of the reports by the Inspectors of Mines have been reproduced in the body of this report.

Numerous references to the Canbelego mines are to be found in a manuscript register of mining localities in New South Wales by Mr. O. Trickett, L.S. It is to be hoped that the register will be published so as to make this valuable addition to our mining literature more readily accessible.

Much valuable information was obtained from a perusal of the Prospecting Board papers dealing with applications for, and grants of, aid from the Prospecting Vote in connection with the Canbelego mines. Mr. W. P. Geary, Secretary to the Prospecting Board, kindly made available all official papers in this connection.

HISTORY.

The facility with which the early history of a mining field is deciphered is generally in an inverse ratio to the subsequent passage of time. This is the experience of those who have attempted to supply the leading facts in the history of the older mining fields of New South Wales, such as those of Orange, the Macquarie River, and Hill End, Emmaville, Tingha, Kiandra, Lambing Flat, Forbes, Parkes, Araluen, the coal and kerosene shale areas, and Cobar. In the case of the Canbelego field, however, it has been found possible to present the leading facts in the history with a fair claim to accuracy. This is due, in great measure, to the recency of the history under discussion.

For the notes here supplied the writer has relied, in the first place, upon information given by Mr. Thomas Reid, a prospector well acquainted with the district; in the second place, upon evidence given in a Warden's Court in connection with an application for a reward for the discovery of payable gold at Canbelego; and, in the third place, upon information contained in the various official publications issued by the Department of Mines.

As with the neighbouring field of Cobar, the greatest difficulties experienced by the early prospectors lay in the lack of water on the plain of erosion [which both includes and surrounds Canbelego], and in the absence of marked outcrops of rocks.

Before the advent of the railway in 1892, and the sinking of numerous tanks, the prospector toiled under very adverse conditions in his search for ore deposits. It appears that Mr. W. Frost, as far back as 1879 or 1880, had found a gossan outcrop on his own land, which he prospected for copper. This was about sixteen years before the discovery of the Mount Boppy lode. The first lease was taken up over a portion of the outcrop in 1886. At a depth of 13 feet carbonates and grey ore were found in the gossan. Thirty tons of the picked ore on assay yielded 38½ per cent. of copper. The following year Frost appears to have disposed of his claim to Messrs. Moodie and Nairn, of Cobar, who erected a reverberatory furnace, and commenced smelting operations. The ore, however, was very poor, the yield from 500 tons, in 1890, being only about 6 tons of copper. Government aid was granted to further explore the mine in 1891, but in 1893 it was closed temporarily.

Frost, in company with another prospector, said to be named O'Leary, sank a shaft to a depth of 60 feet in a dense ironstone outcrop about three-quarters of a mile south of the post office. Gold was found, but not in payable quantities. The date is set down as about 1889.

About the year 1890, a small nugget of gold had been found on the southern slope of Boppy Mountain. A Mr. Souter, who found the gold, sank a shaft at this spot to a depth of about 60 feet. About the same date

another prospecting party sank a shaft to a depth of about 120 feet on the same block, but still further to the east. These mines passed into the hands of a Cobar Company, of which Messrs. Bannister and Cornish were members.

In 1894, a line of reef carrying gold was traced over a mile in length at Restdown, in an area of phyllites and micaceous schists. Fifty men were reported to have been on the ground at the close of 1894. Although the area appears to be suitable for gold and copper prospecting, nevertheless nothing of value appears to have been found, and to-day the workings have all fallen into a state of disrepair.

Chronologically, the next event to receive attention is the discovery of the Mount Boppy gold lode. The better to understand the methods adopted by the prospectors in their search for payable gold reefs it may be stated at this juncture that the Canbelego area is of undulating nature with wide and shallow valleys possessing sides of very gentle slopes and channels choked with alluvium. The main watercourse of the locality heads several miles back of the present township and passes clean over the site of the present Boppy Mine, the lode outcropping in the alluvium. Thence the stream passes north-eastwards towards Florida, intersecting the main Cobar-Nyngan road, about 1½ miles below the mine.

Before the "dollying" of reef "prospects" was commonly practised in the Cobar district, a man, of name unknown, found blocks or "boulders" of a peculiar quartz along the Cobar-Nyngan road, at a distance of about 2 miles distant from Mount Boppy Mine, but could find no gold in them. Ten years later, Thomas Reid dollied the stone and found good gold prospects therein. With this knowledge he commenced tracing the loose "boulders" of this stone upstream in the broad belt of alluvium in the hope of locating the reef from which they had been shed. In this way he was led about a mile upstream to some quartz and ironstone outcrops on the Canbelego-Florida road and about a mile north of the township of Canbelego. Here Reid was led into an error. The "boulders" of peculiar quartz had not been shed by these ironstone and quartz outcrops to which he had been guided in his prospecting, but had been shed by the Boppy lode itself some distance farther upstream. Although Reid knew that the outcrops on the channel slope did not belong to the lode he was looking for, nevertheless he concluded it must be back of the stream a little way, and he decided to search here rather than continue prospecting the upstream alluvium. In this way he followed a gently-sloping ridge of schist up to the Birthday Mine, but not finding the stone he was after he descended another spur of the ridge, and thus found the Hidden Treasure, around which the town of Canbelego is now built. Had he continued in this new direction his track must have led him on to the Boppy outcrop. Reid informed Mr. Michael Delaney O'Grady of his find, and the two apparently agreed to share in any results of prospecting. In the meantime, Messrs. Reid, Budd, Rowland, and Smith took up a mineral prospecting area in the ram paddock belonging to Florida Station, and distant one mile along the Florida-road from Canbelego. A little prospecting was carried out here in the form of shaft-sinking and costeaning. This prospecting area had been pegged out by Mr. William Budd.

According to Mr. Reid, both he and Mr. O'Grady worked at the Hidden Treasure for a few days. O'Grady was accustomed to walk across the outcrop of the Mount Boppy lode to his home near the Boppy Railway

Station. While thus returning from his prospecting operations one evening in the month of September, 1896, he observed the outcrop of the Mount Boppy lode. He secured a "prospect," took it home and dollied it, and informed Reid on the following morning that he had found gold in the stone. Both prospectors thereupon examined the site of the lode under discussion, and, later, pegged out a gold lease of 13 acres and a prospecting area of 7 acres. Reid having temporarily mislaid his Miner's Right, O'Grady proceeded to Cobar to take up the area for both. The prospecting area was supposed to be in Reid's name, and the lease in O'Grady's name. In reality, the official records show that G.L. 9 is a lease of 13 acres taken up by M. D. O'Grady on the 18th September, 1896, and surveyed by Mr. R. H. Cambage, 15th December, 1896, while the prospecting area also stood in O'Grady's name until 1897, when it was taken up as G.L. 21 by a Mr. Marks.

Reid and O'Grady then commenced work on the prospecting area at the spot indicated as the north shaft on the Mount Boppy Company's Mining Plan. Finding that the Hidden Treasure and the Boppy Mines could not be carried on by two men only, they took in two partners. O'Grady took in M. J. Brown, formerly manager of Sussex Station, and Reid took William Budd, an old prospector of the district, into the prospecting area. The prospectors put in a costean, and struck the present Mount Boppy lode at a point about 50 yards from the present main shaft of Mount Boppy. The shaft having been sunk to a depth of 61 feet, aid from the Prospecting Vote was sought to sink to a total depth of 150 feet. Aid was granted.

Mr. M. J. Brown possessed written instructions in April, 1897, from the shareholders to sell the prospecting area for £800, and Budd's area of 10 acres for £200. At this time the shaft was only 110 feet deep. In May, 1897, Captain Dunstan inspected the mine for Messrs. Hardy Bros., but without purchasing. In November, 1897, the leases were inspected for the Anglo-Australasian Exploration Mining Company at the prices just mentioned. The mine appears to have been held in but little favour at the time by the prospectors with the exception of Reid. At this stage the shaft was down a depth of 130 feet, and the remainder of the aid granted from the Prospecting Vote was not made use of by the new owners.

The report by Mr. Inspector David Milne in 1898 gives an idea of the prospecting work accomplished by the new owners within one year of purchase.

> "It was originally worked by O'Grady and Reid . . . . . they sold to the above company, who have still further proved the lode by sinking at intervals, and have now proved it for over 1,000 feet in length and 130 feet deep; on the north end a winze has been sunk 70 feet and another on the south end of workings, thus proving a fair body of stone at each end of the mine at a depth of 200 feet.
>
> The reef averages about 8 feet, and a bulk sample of ore treated at Dapto gave a return of 16 dwt. per ton, and as this sample (260 tons) was taken promiscuously from the heap, it may be reckoned as a fair test. A further test of 1,000 is to be treated before it is intended to erect a plant of their own for treating the ore."*

This is a locality well worthy of thorough prospecting, as similar bodies of quartz are likely to be obtained.

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* Annual Report, 1898, p. 100.

About the same time that the prospectors were proving the Mount Boppy lode, a Mr. Prendergast was prospecting a vein for a Cobar Company consisting of Messrs. Grill, Snelson, and others. According to report the reef was named the Newhaven, because the Melbourne Cup was won at the time by a horse of that name. A shaft was sunk for a depth of 60 feet in the schists near the junction with the quartz felspar porphyry of the Rifle Butts Hill. A small vein was found giving rich returns. After driving for 50 feet to the west at the bottom of the shaft the mine was temporarily abandoned.

At the Birthday, Prendergast obtained prospects as high as 13 oz. of gold to the ton. A shaft was sunk to a depth of 200 feet, and 70 tons of the ore were sent to Cobar and other places for treatment. A return of 25 dwt. of gold per ton of ore was reported. This mine then passed under the control of the Mount Boppy Company. The rich gold shoot appears to have been lost at a depth of about 100 feet.

In the early prospecting stages of the Mount Boppy lode, both Reid and Budd prospected what is known now as the South Boppy property. A shaft was sunk to a depth of about 40 feet and gold veins as "stringers" were found. This area was taken up later by a Cobar Company, who sank the shaft to a depth of 200 feet, and carried out a considerable amount of crosscutting and driving from the bottom of the shaft. A lode was found at 200 feet depth, but it was very small. It was originally known as The Six Acres.

The Anglo-Australasian Exploration Company appears to have expended about £7,000 in development during a season of drought. After prospecting for a considerable period a company was floated in England to work the mine. The name was changed to The Mount Boppy Gold-mining Company, Limited. 168 acres of gold leases were secured. This was in 1900, but owing to the scarcity of water during the dry seasons of that time the mine did not become a producer until 1901, when for a seven months' run, 12,440 tons of ore were crushed and 7,695 tons of tailings were treated for a return of 6,092 oz. fine of gold. The mining machinery included forty head of stampers, poppet heads, winding plant, air compressor, cyanide plant, saw mill, and other items, all valued at £40,000. During the year 1900 the company possessed four shafts, all connected by drives at a depth of 100 feet.

During the period that the Mount Boppy lode was being prospected many attempts were made to find other payable lodes. Among others, Reid and Ranken's shaft was sunk about half-a-mile from the present township of Canbelego. The lode found here was proved on the underlay for 90 feet, thence the shaft was put down vertical for about 80 feet. Exploratory work was carried out from the bottom of the shaft. Nothing of permanent value was found.

Restdown Gold Mines were also prospected vigorously, but the results were not very encouraging.

The history of prospecting operations on this field is similar to that of those of many other mines. The prospectors find a reef and then sell out at a nominal value, and then start prospecting again. With the exception of Reid, the prospectors appear to have had no financial interest in the newly-formed company, as, according to the testimony of Mr. M. J. Brown, they had only a poor opinion of the value of the Boppy reef. Accordingly, after the Mount Boppy had been proved to be a rich lode, we find Budd and party making a determined effort to ascertain the extension of the lode. In

1901 they received aid from the Prospecting Vote to sink a shaft to a depth of 150 feet at a point about a mile distant from the original Boppy workings. At the bottom of the workings the reef had a good appearance, according to the statement of Mr. R. Schloesser.* In August of the same year (1901) Mr. J. J. Saunders found the outcrop of the present Canbelego copper lode, at a distance of about 6 miles in a south-westerly direction from Canbelego. Messrs. Saunders and Longworth then proceeded to prospect the lode for copper.

It will be advisable at this stage to consider the general conditions under which the prospecting community laboured. Man, in common with other organisms, makes a distinct attempt to accommodate himself to the inorganic activities with which he finds himself associated at any particular time. In illustration of this principle, it may be noted that the prospectors of Canbelego were men who found themselves in a subarid country devoid of natural water supplies. In the ordinary season they could make fair progress because water could be stored up in dams, but in periods of protracted drought the water in the small dam of the pastoralist or miner dried up; the herbage and grass perished so that he was deprived of ordinary means of transit. With the decrease of precipitation during summer, the shade temperature was accustomed to increase so as to cause ordinary prospecting to be attended with great discomfort or even with danger. Such a long wave of drought was that which commenced in the western district about the year 1897, and did not pass away until the year 1903. "The protracted drought of the past five years culminated in the lowest recorded rainfall and for 1902 it was only 5·68 inches, of which 3·19 inches—more than half the total—fell in the months of November and December. In the five years ending 1902, it averaged 8·57 inches per annum, as against nearly 18 inches per annum for the five years ending 1897."†

The result of the drought was the suspension of all prospecting and mining operations by the various companies in the Cobar district at various periods with the exception of the Great Cobar Syndicate and the Boppy Gold-mining Company, the former of which secured water for mining purposes from the Government bore at Warren.

Nevertheless, despite these adverse conditions, the Boppy lode was developed to a depth of 300 feet, and a water condensing plant was built in 1902.

The following year the main shaft of the Mount Boppy lode was sunk to a depth of 400 feet, and cross-cutting for the reef was commenced. Preparations were also made against drought conditions, but as subsequent events proved, with only incomplete success.

After years of prospecting, Budd's prospecting area was changed in 1903 to the South Mount Boppy Gold-mining Company, Limited. The area worked by this company adjoins the Mount Boppy blocks immediately to the south. During the same year Hardie and party were prospecting the North Boppy area.

So rapid had been the progress of the Mount Boppy Gold-mining Company that already in 1904 Canbelego was recognised as the premier gold mine of the State. A place which in 1897 was used only for depasturing sheep was now a populous township. During 1904 the main lode had been found at 400 feet depth. Twenty stampers had been added to the battery, making sixty stampers in all, and six cyanide vats had been constructed.

* Annual Report, 1901, p. 89. † Annual Report, 1902, p. 16.

Henry Shaft, Mount Boppy Gold Mine

Henry Shaft, Mount Boppy Gold Mine, 1911.

The slime filter pressing plant had been correspondingly increased, and five Wilfley tables had been added for purposes of concentration. The ore treated this year amounted to about 35,400 tons.

In 1904, Mr. J. B. Jaquet,* Chief Inspector of Mines, prepared a report on the Mount Boppy lode. He appears to have been the first to recognise its nature, namely, that of a "saddle-reef."

Another landmark in the history of Canbelego was the impetus given to prospecting by the discovery of the rich secondary lead ores of the C. S. A. Mine in 1905. That mine, after thirty-five years of unsuccessful prospecting had suddenly given the promise of large and rich ore bodies at a depth of 450 feet. It was the signal for a general prospecting campaign in both the Cobar and Canbelego areas. Especially was the movement aided by the return of better seasons. The Buppe and Rankin's Reward were opened up by this means at a distance of several miles to the south-south-west of Canbelego. These mines were worked for copper in the schist area, but operations ceased with the slump in copper values during 1908. The Boppy Blocks, the Boppy Boulder, the Canbelego King, the Mouramba, the Wealth of Nations, the Canbelego Peak, the Silver-Lead, as well as other mines, appear to have been prospected in great measure at or about the period of the C.S.A. boom. With very few exceptions the results were very discouraging. The majority of these leases appear to have been prospected by sinking shafts to depths of about 200 feet, and then carrying out a considerable amount of cross-cutting and driving.

Henceforth the main interest centres round the Mount Boppy Company and the mines under its control. A considerable amount of driving was carried out on the 400-feet level at the Mount Boppy, and the treatment plant was considerably enlarged. At the North Boppy the main shaft was down 200 feet. A winding plant, compressor, and a pumping plant were installed.

In Bakewell's leases, immediately adjoining the Boppy Mines to the south, a diamond drilling plant was erected for the purpose of finding the southern extension of the lode. The Canbelego King and the Boppy South Companies were still only prospecting.

In all this, we may perceive the determination in the minds of the companies to prove the extension north and south of the main Boppy lode as well as the existence of any possible parallel lines of lode.

The announcement by Mr. Jaquet that the lode was an inverted saddle gave a new direction to prospecting operations.

The following year fresh improvements were added to the Boppy Mine. A "Dehene" filter press and two more cyanide vats were placed in position. A dam capable of holding 10,000 tons of slimes was formed; 300 men were employed on the mine. Prospecting, both for fresh saddles, and the extension of the Boppy lode, was pursued vigorously in Bakewell's leases, Boppy North or Hardie's, the Canbelego King, and the Birthday.

In 1907, the outlook for Mount Boppy Mine was still very bright, and in six years, gold to the value of about £600,000 had been won. The North Mount Boppy shaft was then 370 feet deep, with long cross-cuts therefrom. Of mines outside the Boppy control, the Mount Boppy Copper Mine raised and sold 380 tons of ore for a return of 37 tons copper, valued at £1,816.

* Annual Report, 1905, pp. 69–70, with plans and sections.

The Canbelego Copper Mine also had a new shaft down to a depth of 250 feet, with much driving and cross-cutting from the deepest point reached by the shaft.

At the close of 1908 it was recognised that the Mount Boppy Mine was the largest gold-producer in the State. 380 men were employed, and the value of the machinery was estimated at £100,000. The erection of new machinery was considered, details of which are supplied in the chapter dealing with the Mount Boppy Gold Mine.

Meanwhile, at the South Mount Boppy, Hoffnung's shaft had been sunk to a depth of 310 feet, and hauling plant and pumping appliances had been erected. The Nescham shaft had also been sunk to a depth of 300 feet. At the Mount Boppy Copper Mine a battery of fifteen stampers and concentrating tables had been erected. 500 tons of ore were treated, and the product was disposed of for £800. Twenty men were employed.

In 1909, the number of men employed at the Mount Boppy Mine was 347. The Henry shaft was 520 feet deep. The ore reserves in the mine amounted to 220,000 tons. Much development work was done, and new machinery was erected during the year.

Encouraging prospects were also reported from the south end of Boppy Mountain in rocks of Devonian age.

At the Mount Boppy Copper Mine copper to the value of about £1,840 was won in 1909. The Canbelego Copper Mine also underwent considerable development, and some good copper prospects were obtained.

By the close of the year 1910, the new shaft of the Mount Boppy Mine had been sunk to a depth of 600 feet (Plates I and II). This shaft had been started in January, 1909. Connections were made with the Taylor shaft section at the 500 and 600 feet levels. "In the upper and northern section, the ore body resembles an inverted saddle, the two legs being about 80 feet apart. These have come together south of Taylor's shaft at a depth of 500 feet."* The number of men employed this year was 375. In 1908 the ore reserves were 127,000 tons, whereas in 1910 they had increased to 230,000 tons. The dividends paid represented a return to the shareholders exceeding 300 per cent. on their investment.

At Boppy Boulder, however, and at the Mount Boppy Copper, reports were not encouraging. At the latter mine 48 tons of copper were produced, valued at £2,868. Work was suspended by the company, and the mine leased to a tributing party.

The shaft at the Canbelego Copper Mine was 300 feet deep at the close of 1910. 155 tons of ore won were valued at £1,132.

At the close of the following year the Henry shaft was 727 feet deep. With increasing depth the zinc-blende in this lode was observed to be present in increasingly proportional amounts, whereas in the upper sulphide levels, both blende and galena were present, approximately, in equal amounts. At the Mount Boppy Copper Mine 499 tons of ore had been disposed of for a return of £1,816. The Canbelego Copper Mine had yielded 17 tons of copper—nett value £647—from the treatment of 142 tons of ore.

During the year 1912 the Mount Boppy Gold Mining Company pursued the usual developmental policy, nevertheless movements were hampered by scarcity of water. The chief interest during the year centred about the two lowest levels north of the Henry shaft. At the close of 1911 the company

* Annual Report, 1910, p. 11.

Mount Boppy Gold Mine. General view of Treatment Plant, with Taylor Shaft in background.

had found a large body of ore at the 600-feet level, and at the northern portion of the trough 1,125 tons of ore broken on the western side of the lode yielded 15 dwt. 12 gr. gold per ton.

Henry shaft was sunk to a depth of 816 feet, and sinking has now been discontinued "until the lode at the 800-feet level has been proved by No. 6 winze, which is now being sunk below No. 7 level."*

The ore reserves on the 31st December, 1912, were estimated at 208,597 tons by the management.

The mill ran only 263 days during the year owing to drought conditions. Only 9·64 inches of rain fell in 1912, being a decrease of 10 inches as compared with the precipitation of the preceding year. Advantage was taken of the fact of the mine tank being empty to enlarge its holding capacity, and about 10,000 cubic yards of material were excavated.

A considerable portion of the surface plant was remodelled and a new boiler added to the machinery.

Another feature of the year's work was the erection of a new grinding and filtration plant. "This plant, consisting of tube mills, Dorr thickeners, Moore vacuum filters, and air agitators, with the necessary classifiers, pumps, and other machinery has been erected and is now running, and is handling the output from forty-five head of stamps, the remaining fifteen being still on oxide ore."*

The number of men employed in the mine was 276, and the ore crushed amounted to 53,990 tons.

The Canbelego Copper Mine was worked during the year and produced 404 tons of ore, valued at £2,118. Along the Mount Boppy Copper outcrop, a shaft was put down for 200 feet near the junction of the schists, and the felspar porphyry in M.L. 51. After cross-cutting to the east for about 100 feet a wide ore channel was cut containing secondary copper ore. A parcel of 116 tons yielded 20 tons of copper, valued at £1,575.

The total yield of the Mount Boppy Gold Mine from 1901 to the 31st December, 1913, was £1,277,927, and the total dividends distributed till the end of 1911 amounted to £419,582 13s., on a capital of 121,000 shares of £1 each, authorised and issued. The ore reserves at the end of 1913 were estimated at 200,000 tons.

In 1913 the Block 51 Mine sank the vertical shaft an additional 100 feet. The Canbelego Copper Mine raised 555 tons of ore valued at £3,323.

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* Directors' Report for 1912.

Chapter II.

Physiography.

An imperfect rock shield of flat curvature and of Palæozoic age lies between the streams known as the Darling, the Bogan, and the Lachlan Rivers. An important departure from the form of the shield is apparent in the wedge-shaped area lying between the head waters of the Bogan and the Lachlan. At this locality the shield, instead of being depressed, rises in the form of a low plateau and merges insensibly into the geological structures of the eastern uplands.

This statement needs some slight modification. The southern boundary of the shield is determined, in reality, by the Lachlan only as far west as the neighbourhood of Hillston. Westward of this point it is confined to the north of the Willandra Billabong and thence through to the Darling by way of Mooronanyah Lake, and the many lakes and swamps lying still further west. This boundary appears to have been the course taken by the Lachlan in recent geological time.

It is proposed to call this area the Cobar Shield.

A presentation of the main facts of form and structure in the subject area may enable the reader to gain an impression as to the general appearance of the shield.

Broadly considered, its older geological formations occur in the eastern division; Silurian sediments form long belts approximately meridional in disposition, running for great distances through its more central portions, while the western position is composed of Devonian sediments. Devonian rocks occur also as outliers over the entire area. Granites, serpentines, hornblendites, norites and diorites, and long lines of Palæozoic lavas are visible in the older formations of the northern, eastern, and south-eastern portions, while Tertiary basalts and stream drifts occur in various places in the northern position. Westwards and northwards the shield passes under the broad alluvium of the Darling; eastwards, it passes under a southern prolongation of the Great Artesian Basin of Australia, while southwards it dies away beneath the Salt Bush Plains of Riverina. Only to the south-east is it continuously connected with the older rocks of the eastern portion of the State. Its length from Bourke to the Lachlan is about 250 miles, while its breadth is about 200 miles. Broadly it is a plain, dotted with residuals varying from 100 to 800 feet above the general level, the residuals being crowded together along lines of certain dense porphyries and quartzites, otherwise the surface is only diversified here and there by hills of moderate height. Considered in more detail the surface of the shield is not smooth, but rather it is mildly roughened by broad but shallow valleys, which join each other with accordant grades. The drainage is approximately radial, the streams heading in the neighbourhood of Canbelego and Nymagee. At Canbelego the general level of the plain is higher than at any other point, and here also the stream valley forms are more pronounced than at other localities on the shield, except at the tongue of Palæozoic rocks in the south-eastern portion, by which it is co-extensive with the western foothills

of the eastern highlands. Even at this central divide, however, the channel bases have been choked with alluvium. A decreasing rainfall would be a sufficient explanation of this phenomenon, seeing that pebble drifts underlie the shallow alluvium.

The general level of the central plateau at Canbelego is 1,000 feet, and the intervalley ridges with summits at accordant levels rise about 100 feet above the plain in the hard sandstone belts lying immediately south and west of Canbelego. At Cobar the general level is 800 feet; the valleys are well defined, but are shallower and broader than the Canbelego examples. At Nymagee the country has apparently fallen to about 700 feet above sea level. Wilcannia, Louth, Bourke, Nyngan, Condobolin, and Hillston are the main settlements situated along the boundaries of the shield with heights respectively of about 300, 325, 350, 550, 650, and 500 feet above sea level.

Neglecting for the present the question of its height above and distance from the sea, the surface of the shield appears to represent a peneplain, or surface formed by subærial erosion. The evidence for this is fairly conclusive and may be stated as follows:—

(*a*) The arrangement of the draining valleys is almost radial. These have been already described.

(*b*) The contorted strata have all alike been bevelled off by the plain, their edges ending abruptly against its surface.

(*c*) The residuals generally increase in height above the surface of the shield on a traverse outwards from the short longitudinal axis of the central portions.

Thus Mounts Boppy and Geweroo—the highest points at Canbelego—rise to heights of about 360 and 300 feet respectively above the plain, or about 1,350 and 1,275 feet above sea level. Nurri Mountain rises 500 feet above the plain, 20 miles south of Cobar. At Nymagee, Gilgunnia, Shuttleton, and in the neighbourhood of Bobadah, porphyry and Devonian hills rise to heights of 700 and 850 feet above the general level. In the Mount Hope and Condobolin areas hills occur with heights comparable with those just mentioned, while at Gundabooka, Booroondarra, and other areas lying in the north and north-western portions quartzite and sandstone hills rise from 600 to 900 feet above the low-lying plain. Eastward of Canbelego, however, in the direction of Nyngan, this rule does not obtain. Here the horizontal element in the landscape is strongly marked and the plain surface is rarely diversified by hills and valleys. This absence of striking topographic relief is explicable by reason of the relative weakness of the older slates and schists forming the rocks in that area. Such features suggest that a plateau has been subjected for a long period to the action of subærial erosion with the production of a plain-like surface having its highest general level at Canbelego.

The next consideration is the height above sea level at which this surface was excavated. The shallow and broad but well-formed valleys which head in the Canbelego-Nymagee district, and which open out towards the periphery in valleys scarcely to be distinguished from the surrounding plain, suggest a slight uplift of the area in later geological times with corresponding formation of shallow valleys. Those who would assume a depression for the area in recent time to account for the recent choking or silting-up of the stream channels must remember that decrease in rainfall

is a sufficient cause for such phenomenon. Those, on the other hand, who would assume a recent elevation of the central area of the shield to account for the height of the same above sea level, must remember that in the first place the disposition of the valleys suggests that the stream system has not been disturbed in recent geological time, and on the other hand that the drainage has to travel possibly from 1,200 to 1,500 miles to the sea. Under such conditions a plain of erosion could be formed at heights above sea level greater than one formed, say, only 100 miles from the coast, all other conditions being equal.

The question of the age of the peneplain is uncertain. Tertiary drifts appear to overlie it near Coolabah, while Cretaceous deposits are shown on the geological map as abutting against its north-western portions. It is probable that this surface of erosion was completed in Cretaceous or early Tertiary time, and that the broad valleys which extend into the heart of the local divides represent later and post-Tertiary erosion. The isolated summits rising to heights of about 1,400 feet above sea level suggest the existence of a former plain of erosion.

The peculiar association of this rock shield with the widespread Riverina alluvial plains on the south, and the Great Artesian Basin, to the north and east, suggests that the Cobar Shield has been a light or buoyant portion for a long period of time, while the associated areas have been relatively heavy portions, of the earth's crust, which have been bowed down while the shield has been buoyed up. As already stated the shield is tied to the main geological complex to the east by means of a relatively narrow Palæozoic rock mass.

Residuals.—As regards structure, these fall into two groups, one comprising long, low ridges covered with dense mallee growths, the ridges being more or less discontinuous, the other comprising isolated hills rising decidedly above the long ridge lines just mentioned, and being disposed in long meridional lines or as isolated peaks.

The low ridges consist of relatively hard belts of schists and sandstones covered with whipstick mallee in the oldest rock groups of the field; the detached points consist of dense Devonian sandstones and quartzites covered with mallee and pine, while the high points which possess a meridional disposition consist of quartz-felspar porphyry lavas. The porphyries are covered in places with dense pine growths while the foothills of the same rock group are clothed with wattle (*Acacia decora*), Red Gums (*Eucalyptus dealbata*), and She Oaks (*Casuarina stricta*).

Relation of the fauna and flora to their geological environment.—Owing to the prevailing subarid climate grass is not common, but herbage is plentiful in good seasons, and small plants of xerophytic habit are abundantly represented, whose fruits mature in the spring and early summer.

Burrs and hard spiny processes on the seeds and fruits of these herbs and undershrubs are common.

A list of the larger plants has already been supplied. Of these, the mallees are eucalypts possessed of large root-stocks, from which numerous stems spring; the leaves are relatively small, they are hung vertically, and are rarely far from the ground, so as to avoid the desiccating action of the wind. Oils and mineral wax are secreted by the eucalyptus also, apparently to protect themselves against desiccation.

The eremophilas and the acacias also exhibit beautiful adaptations to droughty conditions.

Bird, insect, spider, and centipede life is abundantly represented, while reptiles such as snakes and lizards are fairly common. Emus, galahs, pigeons, bowerbirds, and other bird groups are still common, but the bielby (*Thylacomys lagotis*), the kangaroo, and the wallaby have almost disappeared. Rabbits and foxes have been introduced, and are pests.

Subarid weathering and soils.—The reader is referred to the Cobar Copper and Gold Field Report, pp. 30-32, for a general description of this interesting subject. It is sufficient here to state that the tendency of the underground water (which is more or less charged with minerals in solution) is to rise to the surface under capillary action induced by the desiccating action of the surface winds in summer, and there to deposit its mineral contents upon the evaporation of the water. A small deposit of calcareous tufa has been thus deposited near the Territorial Fence about one mile south-west of Canbelego, while the lime tufa found in surface joints, and which forms a general cement to the outwash from the hills, also arises in this way.

Many of the local ironstone outcrops have a similar origin, and may be observed to have lost their iron contents at shallow depths. Magnesite nodules and manganese concretions and films also arise in this way.

The soils are prevailingly reddish, by reason of an iron-oxide content which has been subjected to a strong and long-continued heating action by the sun in well-drained situations. In contradistinction to this those soils in the central western areas, such as the Lachlan alluvium at Forbes, which are periodically covered by water for considerable periods, are commonly black or dark-grey in colour.

The properties of soils such as these appear to be very different. Those which are black or dark-grey in colour appear to possess an appreciable amount of carbon, which dries into hard, tough clods, while the chocolate to red varieties are adapted for the cultivation of wheat and other produce, in areas of moderate rainfall. Owing to the sub-aridity of the climate and the general lack of surface relief in the area under consideration, the nutritive qualities have not been abstracted from the soil.

Chapter III.

GENERAL GEOLOGY.

Rocks.

General Statement.

Cross-bedded sandstones of fine texture, with slates, claystones, and cherts of Palæozoic age, comprise the greater portion of the Canbelego rocks. Associated with them are porphyries and rhyolites. A few very small outcrops of basic igneous rocks occur within the older members of the Palæozoic sediments. Among the sediments argillaceous sandstones are exceedingly common, while slates and claystones are present in subordinate degree. Well-bedded cherts occur in two belts each many miles in width. Conglomerates, quartzites, and tuffaceous sediments are fairly abundant in the younger members of the various series. Rock types, approximating to phyllites and schists, are not uncommon in the more altered sedimentary groups.

The Section in General.

In a traverse extending westerly from Nyngan to Barnato Lake, a distance of 132 miles, the first portion, amounting to about 11 miles in length, would be over the alluvium of the Bogan River, which here conceals the older sediments of the district. In this section the alluvium is in the nature of a thin wedge, being several hundreds of feet in depth at Nyngan and dying out near the Miandetta and Summervale platforms on the Nyngan-Cobar and Nyngan-Bourke railway lines respectively. Immediately the "red soil" plain of the Bogan River had been crossed an interesting group of sandstones, quartzites, slates, phyllites, and schists would be met, which extends westwards to a point a few miles beyond Hermidale and about 10 miles north-westerly of Girilambone. The members have a prevailing strike of about N.N.W., and the harder belts form long, low, broken, and rounded ridges. The quartzites, however, which occur in several long and subparallel lines form rough, broken ridges of moderate height, upon which trigonometrical stations have been erected. The prevailing dips of the quartzites were not ascertained because of the metamorphism to which the beds had been subjected.

Continuing the traverse it would be noted that sandstones and claystones occupy a wide belt, lying between the schistose sediments just mentioned and a locality about 38 miles east of Cobar along the Nyngan-road. The character of the sediments are different here, cherts, claystones, and argillaceous sandstones forming the characteristic types. Of these the cherts and claystones are highly crumpled and well bedded, but they do not appear to have been metamorphosed to an appreciable extent. Conglomerates and tough shales form the western margin of this belt. On account of the close folding, and the lack of relief, in the country traversed, the prevailing dips of this wide series have not been ascertained. The general strike of the

sediments is almost N.N.W., and at the Florida Trigonometrical Station, about 6 miles north of the Florida Railway Station, the conglomerates and shales are strongly folded, with a dip prevailingly westerly in direction, and a value of about 60 degrees. This, however, cannot be accepted either as the average value or even as the prevailing direction of the dip, because there exist very few other large outcrops yielding average local dips in the district, and the rocks are so closely folded as to suggest caution in accepting any local dips as being typical of a district, or even of an area exceeding one acre in extent.

Thirty-one miles from Cobar the cherts and claystones give place to rhyolites, quartz-felspar, porphyries, and tuffs, which stretch in unbroken manner for a distance of 12 or 13 miles. The tuffs, the flow structures, and the glassy bases of the types suggest an extrusive origin, while their intimate association to the east, with the cherts, is very interesting. For a distance of about 13 miles in a direction approximately meridional the porphyries under consideration separate these cherts from the rocks lying to the immediate west which, in turn, are schistose and have an older appearance than the cherts and their allies. Mining operations at the Mount Boppy Copper Mine both at and near the junction of porphyries and schistose sediments indicate a very steep dip for the junction of igneous and sedimentary rocks at this point. In this report the porphyries are considered as a series of contemporaneous flows overlying the main mass of the cherts, the whole resting upon a metamorphic basement.

For the important group of cherts and associated rocks the name Ballast Series is here suggested, because the ballast for the railway line in the district is obtained from the cherts.

Immediately west of the porphyries the Canbelego sediments proper have a strong development. Eastward of the Boppy Railway Station the general dip of the series was not ascertained, but westward of the Mount Boppy Gold Mine, for a considerable distance, the prevailing dip appears to be westward at a high angle. Cross-bedding, close folding, puckering (Plates IV, XXI), and schistosity are marked features of the series, and mining operations appear to be confined to this wide belt, in which mica schists, phyllites, slates, quartzites, and argillaceous sandstones are plentifully represented. Similarly the Girilambone and Hermidale series of schistose rocks lying to the east of the Ballast group, contain numerous metalliferous deposits as at Girilambone and Hermidale themselves, at Miandetta, Wilga Downs, and the Budgerygar Mines, while the Ballast Series contain no metalliferous deposits of value.* For the Girilambone, Hermidale, and associated sediments the name Girilambone Series is here suggested, while for the group in which the Canbelego ore deposits occur the name Canbelego Series is proposed.

Devonian sediments, consisting of conglomerates, sandstones, shales, and tuffaceous material occur as outliers in the Canbelego Series, and their general dips appear to be gentle, rarely exceeding 20 or 30 degrees; nevertheless here and there they have been pinched up into narrow folds of very steep dip within the older Palæozoic basement. (See General Sections.)

Sixteen miles eastward of Cobar both the schistose and puckered appearance is lost and steeply-dipping sandstones and claystones take their place,

*See also a similar peculiarity recorded for Forbes-Parkes. E. C. Andrews, Report on Forbes Parkes Gold-field. Mineral Resources, No. 13, 1910, p. 21.

these being devoid of cleavage and exhibiting but slight traces of metamorphism. These types pass beneath the alluvium of Yanda Creek between the 12 and 10 mile pegs, but reappear at the 10 and 9 mile pegs. The dips of the sediments in this locality are high.

Near the Weltie Trigonometrical Station, lying about 8 miles east of Cobar, cherts, claystones, tough shales, and argillaceous sandstones are again met with, and here, as to the east of Canbelego, the cherts form the highest points in the neighbourhood. The series approaches to within 2½ miles of Cobar, and near the Lucknow and Wild Wave Mines its members are associated with conglomerates and sandstones, which, in turn, are strongly suggestive of those associated with the Ballast Series to the east and north of Canbelego. Evidently the Ballast and Weltie Series represent the denuded limbs of a great fold, although the position of the conglomerates is puzzling, and suggests the action of close, rather than of simple, folding. At present, it is not known whether the structure of these old sediments is of the nature of an anticlinorium, or a synclinorium.

Westward of the Weltie Series lies the metamorphosed belt of sediments in which the famous Cobar copper ore deposits occur. These consist of slates and sandstones, highly cleaved and possessed of a prevailingly high westerly dip. Heavy faulting action appears to have affected this important group of rocks.

The Water Tower, Alley, and C.S.A. series, which are, possibly, Silurian in age, possess strikes subparallel with those of the Cobar group, and although strongly folded they dip very steeply to the west. Traces only of cleavage occur in these beds, but the high general dip and the crushing of conglomerate pebbles found in them suggests an age older than Devonian.

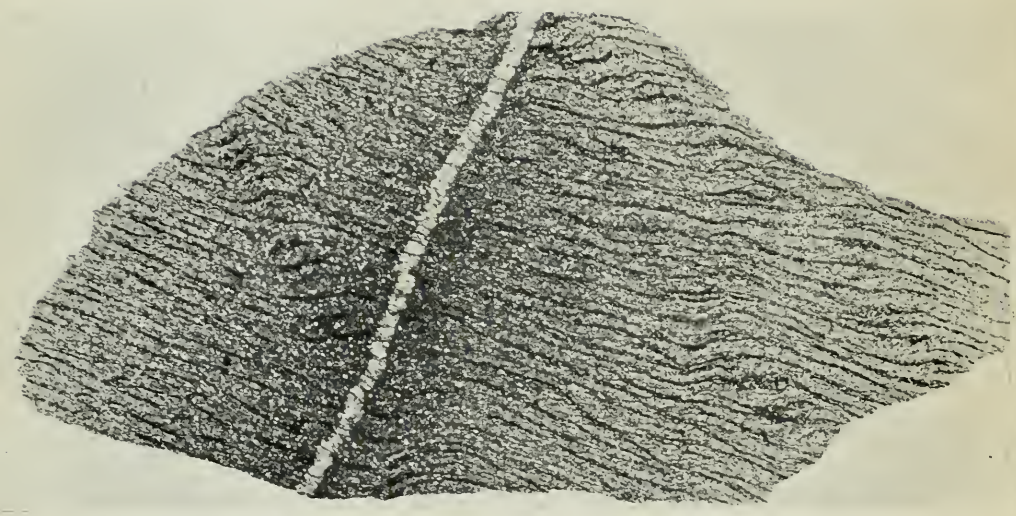
Several miles to the west of Cobar Devonian sediments outcrop. These have a very large development towards the Darling River, both in a north-westerly and a south-westerly direction. The dips are characteristically gentle, interrupted in places by local infoldings within which small areas of the younger rocks have been strongly folded within the masses of the older rocks. Signs of cleavage and metamorphic action were not observed, moreover the shales have not been hardened.

Palæozoic Sediments.

The Canbelego Schists, Slates and Sandstones. (Pre-Silurian ?)

General Character and Distribution.

Sandstones, quartzites, slates, phyllites, and schists.—Cross-bedding is a characteristic and frequent feature. The series is widely distributed, being found at Canbelego itself and for distances of 1½ miles east and 10 miles west of the township respectively. The northern extension is considerable, while that to the south is beyond both the Restdown Mines and Station where, in turn, it is overlain by Silurian and Devonian beds. Beyond the great development of the Devonian quartzites to the south of Restdown the series again outcrops near the Nymagee Head Station and extends also north-westerly from Restdown towards Mount Nurri at the northern end of the Rookery Station.



(*a*) Photograph of Puckered Quartzite. A narrow quartz vein traverses the specimen. The individual beds are very thin. x $1\frac{1}{2}$.

(*b*) Puckered Argillaceous Sandstone, from long cross-cut in North Mount Boppy Mine.

The Girilambone Series described below probably belongs to the same great group as the Canbelego sediments.

Detailed descriptions.—The relative positions of the Canbelego and Ballast Series are indicated on the general maps and sections.

Claystones.—On the surface these vary from reddish, pink, grey, yellowish, to whitish in colour. They have a strong development east of the township of Canbelego, as also west of the same locality. The usual method of occurrence is as thin beds alternating with laminated sandstones. The whole series is usually contorted and minutely puckered. Plate VII (*b*) is a detail of a common association of claystone and sandstone. In fresh fractures the details of structure are difficult to make out, but on weathered surfaces, as in the railway cuttings of recent formation the details of structure may be made out easily. Some of the types are well-bedded.

Analysis of ironstained Claystone 6 miles west of Mount Boppy Station.

	986/13.		986/13.
SiO_2	76·33	V_2O_5	absent
Al_2O_3	13·35	SO_3	*a trace
Fe_2O_3	1·95	Cl...	* ,,
FeO	0·36	S (FeS_2)	absent
MgO	0 63	Cr_2O_3	,,
CaO	0·07	NiO, CoO	,,
Na_2O	0·51	CuO	*a trace
K_2O	2·74	MnO	0·03
H_2O-	0·46	BaO	0·03
H_2O+	3·12	SrO	†present
CO_2	0·02	Li_2O	† ,,
TiO_2	0·60		
ZrO_2	absent		100·30
P_2O_5	0·10		

Specific gravity, 2·690.

* Less than 0·01 per cent. † Spectroscopic reaction only.

(Analysis by Mr. W. G. Stone.)

In this the silica percentage is very high, the alumina low, and the iron, lime, and magnesia oxides very low, indeed, the rocks of which this is a type may be classed as finely-textured argillaceous sandstone rather than slates.

Slates.—Rocks of these types are closely associated with phyllites and mica schists, as at the Shangoes and the Canbelego Copper Mines, or with cross-bedded contorted and puckered sandstones as at the Canbelego locality itself.

At the Shango Mines the predominating colours are grey, greyish, green, dark grey, greenish grey, bluish black. A silvery sheen is common, and the rocks frequently pass into phyllites and schists. Minute puckering is a common feature, but it is obscured owing to fineness of texture. The cleavage is generally at right angles to the bedding planes where observed. The bedding planes, however, are rarely obliterated.

Schists.—These are of various types. All show the effect of great contortion and minute puckering. Silky slates, or schists, are terms applied to certain of these rock types.

To the south of the Shango Mine a large belt of mica schist makes a bold and wide outcrop. Near the surface the colours are grey, pink, and red. The schist appears to have been derived from the metamorphism of an argillaceous sandstone, the individual sand grains being drawn out into long or short "eyes," and the cementing material being transformed into mica, which envelopes the "eyes" in the form of sheaths. Fig. 1 illustrates the association of sand grains and mica in the schist.

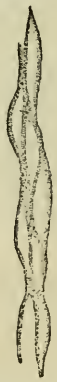
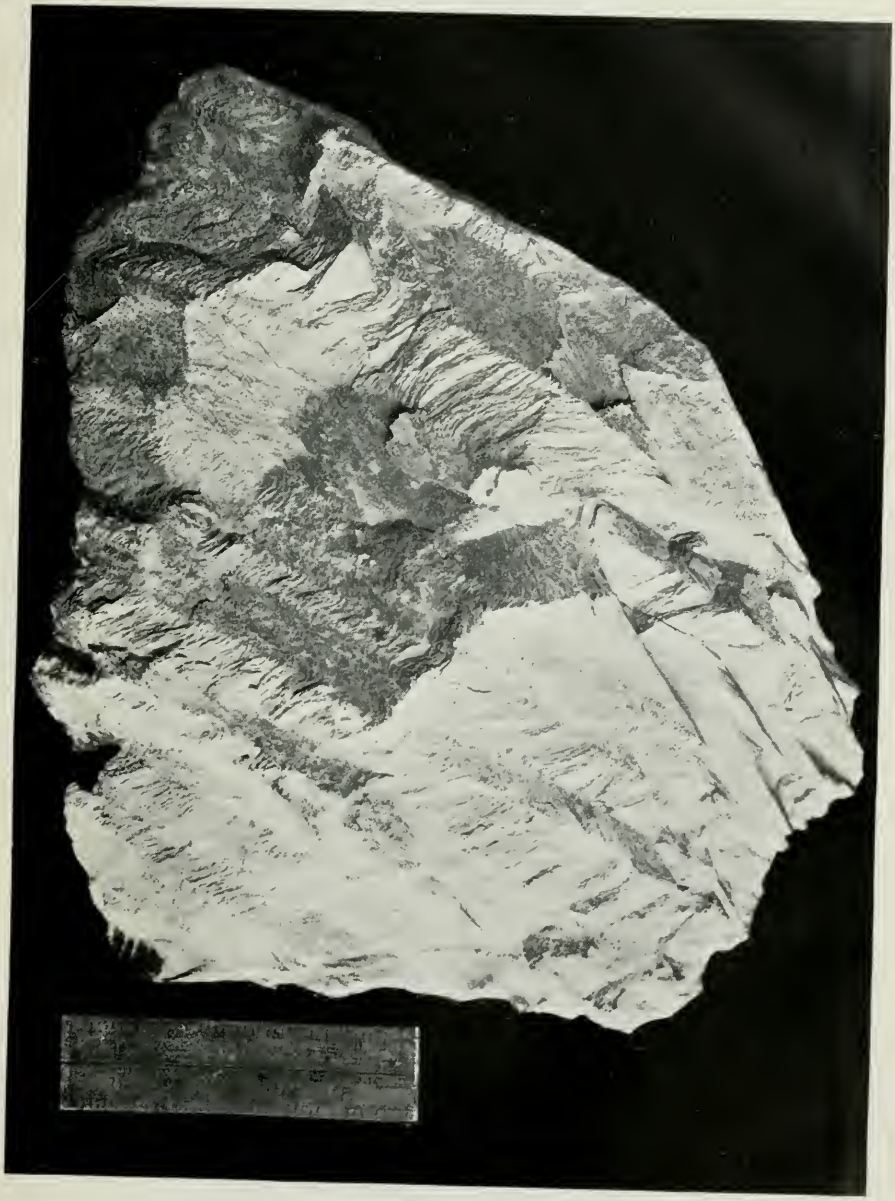


Fig. 1.—Mica schist from south of Shango Mine. Sand grains drawn out in forms of "eyes."

Sandstones.—These are a most interesting group of sediments, whose common associates are quartzites, claystones, slates, and schists. Perhaps the most curious points in connection with them are their texture, cross-bedding, folding, puckering, and their association apparently indifferently with either schists or claystones.

Texture.—The typical absence of coarse sand grains is very marked in the sandstones of this large area. In fresh hand specimens they are frequently suggestive of shales and slates, but upon weathered surfaces the traces of cross-bedding are easily made out, while under a lens the sandstone character is at once apparent. In numerous instances the sand grains have been flattened and changed to a shape somewhat lenticular, the abundant cementing material of argillaceous nature having been altered in such a manner at the same time as to suggest a partial alteration to schists.

Cross-bedding.—False or cross-bedding phenomena are extremely common, and throw considerable light upon the mode of origin of the sediments. In this connection it must be understood that the lines in the figures herewith (Fig. 5) are not supposed, necessarily, to represent the actual angles of dip of the false to the true bedding planes, but represent merely the apparent false bedding planes as seen in the sides of crosscut, drives, and other mining workings. In fact, a frequent value of the apparent false dips is 40 degrees, or a figure apparently too high for the angle of repose of sand and clay particles in mass. The high value of these dips appears to be due to the influence of compressive agencies.



Puckered Sandstone, from long crosscut in Mount Boppy Gold Mine. x $\frac{1}{3}$, approximately.

Cross-bedded Sandstone from Weltie Beds. About 8 miles east of Cobar.

Evidence of contemporaneous erosion is also very common in connection with the cross-bedded material (Plate VI). In common with the planes of true bedding those of cross-bedding are set closely together. Indeed most of the arenaceous sediments appear to be laminated.

Folding.—In the railway cuttings the sandstones may be observed to be strongly folded (Fig. 2), and crumpled into a complex series of symmetrical synclines and anticlines. On this account the observed dips in the small cuttings and quarries are useless for purpose of estimating the general structure of the region.

Puckering.—The accompanying sketches and plates (Plates V and XXIX, and Fig. 5) illustrate the marked degree to which this feature has been carried in the Canbelego district. In Plates XXI, XXII the sediments so puckered are the cross-bedded varieties, and the apparent bedded planes are those of cross, and not of true, bedding. It must not thus be understood that true bedding planes have not been puckered nor folded, but rather that the small cross-bedded elements of the coarser sandstone types admit of puckering more readily than the group of such elements bounded by two true planes of bedding. This association of the folding, and the puckering, of true and false-bedded masses is illustrated in Fig. 5. The falsely-bedded sediments constitute a weakness in the main folded rock mass. The puckering action, however, appears to be capriciously distributed, and this feature is also illustrated in the figure.

Nevertheless it may be noted that in the more compact laminæ, which have been cemented together, the evidence of puckering is not nearly so marked (Plate IV [*a*]), whereas in those rock types in which the formation of mica has taken place without the accompaniment of cementation of bedding and false-bedding planes by a process of silification there have been the most marked examples of puckering.

In certain varieties of sediments, such, for example, as thinly bedded claystones and sandstones in association, the weaker layers are so rolled and squeezed as to suggest plasticity of rock flowage, the appearance being that of a mass of plasticine, which has been subjected to strong side pressure under moderate load. The coarser layers appear to have been strongly puckered while the more plastic claystones have been moulded into them. (Plate VII [*b*].)

A peculiar optical effect is produced by the strong puckering. Viewed in certain directions long silky or glistening parallel bands appear to traverse the faces of the puckered sandstones. The cause of the

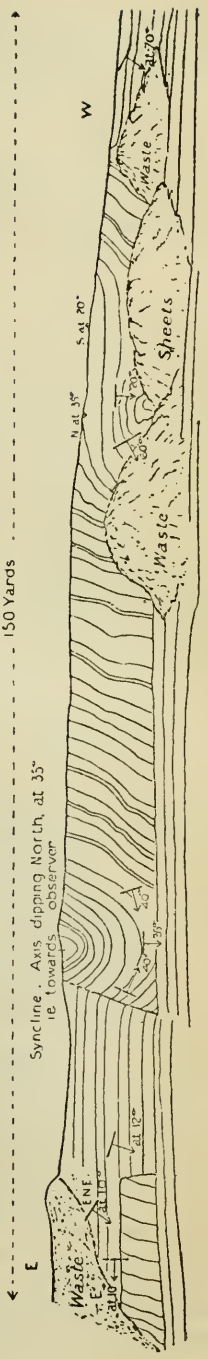


Fig. 1a.—Sketch section across radiolarian cherts and claystones in Railway Quarry, about 8 miles east of Canbelego.

phenomenon is to be sought in the unequal reflection of light from the opposed limbs of numerous small anticlines arranged in parallel order both under and alongside each other by the puckering to which the laminæ of the sandstones have been subjected. A partial recrystallisation of minerals along the false bedding planes has aided materially in producing this optical effect.

Quartzites.—In common with the sandstones the quartzites are fine in texture and the sediments themselves are arranged in very thin beds, attaining, however, a considerable thickness when taken as a group. The colour is greenish grey.

Association of Schists, Claystones, Slates, Sandstones, and Quartzites.

Upon casual inspection it seems peculiar to find sediments, in close association, of such diverse types as shales, slates, schists, sandstones, and altered quartzites. However, it is not uncommon in Canbelego to note the occurrence of altered, folded, and puckered sandstones, with intercalated beds of rocks, which appear to be shales, but which in reality are claystones, devoid of cleavage. The structures which, upon first examination, appear to be cleavage, are merely bedding planes set very closely together, and along which there is a considerable development of light-coloured mica. Moreover, such structures always parallel the bedding planes of the associated and folded sandstones. (Fig. 2.)

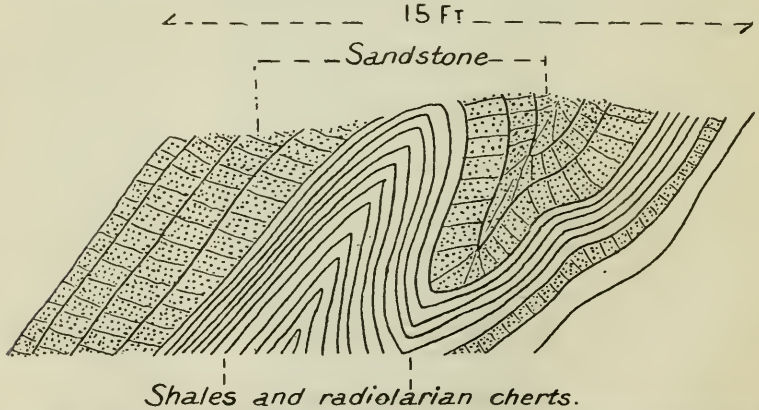


Fig. 2.—Association of tough shales and radiolarian cherts in railway cuttings, 3 miles east of Cobar.

The association of slates, phyllites, and schists is not so strange, nevertheless. From a study of hand specimens, the more coarsely textured rocks appear to have suffered heavily, whereas the slates appear to be of the ordinary variety. The most peculiar assemblages, however, consist of sandstones, which apparently differ but slightly from ordinary varieties of unaltered sandstones, such sediments nevertheless occurring in the vicinity of intensely crumpled and schistose sediments, and all apparently of the same age. A similar association occurs at, and in the vicinity of, the Budgery Mines, 25 miles to the east.

Analyses.—The accompanying analyses of the phyllites also furnish a general idea as to the chemical nature of these sediments. An analysis of a typical Cobar slate is here inserted in the table for purposes of comparison with the Canbelego types:—

	977	985	891
Silica	64·88	57·68	62·12
Alumina	15·71	19·73	18·90
Ferric oxide	5·05	1·60	1·75
Ferrous oxide	1·39	7·20	4·41
Magnesia	2·09	3·33	2·72
Lime	0·60	0·16	0·78
Soda	0·87	0·14	0·29
Potash	4·95	4·56	4·86
Water (100° C.)	0·47	0·14	0·33
Water (100° F.)	3.36	4·24	3·10
Carbon dioxide	trace	0·01	.....
Titanium dioxide	0·35	0·75	0·75
Zirconium dioxide	nil	nil	.....
Phosphoric anhydride	0·09	0·14	0·14
Sulphur trioxide	nil	nil	nil
Chlorine	trace	nil	.....
Ferric sulphide	nil	nil	.....
Chromium sesquioxide	nil	nil	nil
Nickel and cobalt protoxides	trace	trace	.....
Manganous oxide	0·03	0·05	0·05
Baryta	0·09	0·05	0·04
Strontia	nil	nil	trace*
Lithia	nil	nil	trace*
Vanadium oxide	trace	nil	nil
	99·85	99·78	100·24
Specific gravity	2·758	2·831	.....

* Spectroscopic reaction only.

977. Phyllite, 3 miles W. of Canbelego. Analysis by Mr. H. P. White, F.C.S.

985. Phyllite. Analysis by J. C. H. Mingaye, F.I.C., F.C.S.

891. Clayslate, from near the "Peak," Cobar. Analysis by Mr. W. G. Stone. "Trace" equals less than 0·01 per cent.

Conditions of Deposition.

In the whole area occupied by the Canbelego Series, there is a marked absence of coarse sandstones and of limestones, the members consisting in the main of finely-textured sandstones (well cross-bedded), and of sandy shales and slates. A deposition of material either by wind action or by shallow water, but at a slight distance from land, is suggested. Sedimentation on a shallow and subsiding sea floor would afford a sufficient explanation of the occurrence, although there is nothing, in an examination of the sediments themselves, to oppose the idea of origin in part, by stream and wind. In this connection it is advisable to note that coarse conglomerates and augen sandstones occur about 20 or 25 miles farther west; that they have an almost meridional disposition, and that their phase of metamorphism is very similar to that exhibited by the Canbelego Series. This would suggest an old shore line of age comparable with the Canbelego Series.

Age and Correlation.

In the absence of palæontological criteria of age for the Canbelego Series, it is advisable to classify them provisionally on lithological grounds.

In the Report on the Cobar District,* the conglomerates, sandstones, and slates of the Cobar Series were provisonally classed as altered Silurian sediments. The Canbelego Series appear to be of the same age as the Cobar sediments, but striking differences exist between the slates, phyllites, and schists of the Canbelego and Cobar areas, as compared with the rocks known to be of Silurian age in those areas. In dealing with the exposures of these more altered sediments in the Cobar area, it was noted that the rocks exhibiting signs of strong cleavage and distortion were confined to narrow belts, and on this account it was considered that the metamorphism had probably been occasioned by faulting or shearing action being confined to zones of limited width. The study of the Canbelego and Girilambone Series, however, affords evidence of the great extension of the slates, phyllites, and schists, the action here having been regional. It was therefore considered that the Cobar Series had been faulted up among the younger sediments of the district.

The following notes on this subject are based on the lithological characters of rocks existing in Australia west of the Great Dividing Range of Eastern Australia.

A study of the formations of the north-eastern portion of New South Wales shows that there is a succession from east to west of rocks progressively younger in age, and that rocks even as young as Permo-Carboniferous have been intensely crumpled and metamorphosed.†

On the other hand, a study of Australia in areas outside of Eastern Australia northward of Sydney suggests that the continent was built from west to east in Archæan, Cambrian‡, and Ordovician times, and that the Silurian and Devonian form groups which are transgressive over the older sediments. Thus the pre-Cambrian may be considered to predominate as from Western Australia to the South Australian border; the Cambrian in great measure occupies an area extending from Adelaide to a point well beyond the Broken Hill area to the east. The Ordovician appears at Forbes-Parkes, Lyndhurst, The Shoalhaven, and Eastern Victoria, while the geology of south-eastern New South Wales suggests that many areas may have to be placed hereafter in the Ordovician which heretofore have been included within the Silurian. For example, the large areas of schistose and puckered rocks in the area between Goulburn and Bathurst, in the Wagga, Hill End, and other areas will, probably, be found to be of pre-Silurian age. In this connection it may be stated that the rocks of southern New South Wales in which auriferous deposits of economic value have been found are mainly pre-Silurian in age. In the writer's experience, sediments of definite Silurian age in extra New England§ areas do not contain either auriferous or argentiferous deposits of commercial value.

The Silurian sediments in South-eastern Australia are abundant from the Darling River to the coasts of Southern New South Wales and of Victoria. They appear to overlie a basement of Ordovician sediments, the latter having been very strongly and closely folded before the deposition of the

* Mineral Resources, No. 17, p. 52. † E. C. Andrews, Report on Drake Copper and Gold-field, Mineral Resources, 1908, pp. 10, 11. ‡ See also H. I. Jensen, Procs. Roy. Soc. Qld., 1912, pp. 153–155. § New England is here considered to embrace the area from the Hunter to the Queensland border and inland far west as Texas, Moree and Narrabri.

Silurian. Characteristically the Silurian are not much metamorphosed except in places where they may have been locally pinched within the floor of the older basement.

As with the Silurian, so also the Devonian sediments occur indifferently throughout New South Wales, in areas outside New England as masses of gently or moderately folded sediments overlying Silurian and pre-Silurian basements, excepting in certain restricted areas where they have been sharply folded, as at the Murrumbidgee, near Yass, Rydal, and Yalwal.

The province of New England is not considered in this connection, as it appears to possess a history peculiar both to itself and to Eastern Australia still farther north.

The characteristic sediments of the Silurian appear to be claystones, cherts, fossiliferous limestones, and other types not strongly metamorphic. Aureoles of metamorphism, however, occur around the igneous massifs.

Ordovician sediments comprise carbonaceous shales, claystones, slates, sandstones, phyllites, and allied types. Close folding appears to be everywhere characteristic of the Ordovician in New South Wales, and a strong unconformity between it and the Silurian also appears to be general.

The sediments of Cobar, Canbelego, and Girilambone, however, do not bear any close resemblance to sediments of known Ordovician age, either in New South Wales or Victoria. In the first place the metamorphism to which the Cobar, Canbelego, and Girilambone Series have been subjected is more pronounced than that to which sediments of known Ordovician age in New South Wales and Victoria have been subjected. This in itself is suggestive of an age at least Ordovician for the series under discussion, because, as stated elsewhere,* the western and southern portions of Eastern Australia have not been visited by strong compressive movements since the mid-Palæozoic, whereas the north-eastern portions of that vast territory were strongly compressed at the close of the Carboniferous and the Permo-Carboniferous Periods. In other words, areas such as Cobar, Canbelego, and Girilambone have not been affected by orogenic activities at periods later than have those of Victoria and Southern New South Wales. Such being the case, it is suggested from considerations of metamorphism alone (the influence of igneous massifs being characteristically absent), that the Cobar, Canbelego, and Girilambone Series are pre-Silurian.

The case of the Cambrian sediments may be considered at this stage. Rocks of definite Cambrian age occur at Adelaide, and thence to the Broken Hill area,† and consist of massive conglomerates, quartzites, slates, and limestones. In a note to the writer under date 19th May, 1913, Mr. W. Howchin‡ states: "The Cambrian of South Australia are in two series, distinguished chiefly on lithological grounds. The upper series is much less altered than the lower, and has a preponderance of purple-coloured rocks, chiefly slates (or shales) and quartzites. It contains, however, some exceedingly fine-grained siliceous quartzites of a lightish colour. Near the upper part of the series are numerous limestones—oolitic at times, and at some horizons, fossiliferous. In the lower series there are no purple rocks, slates and phyllites predominating; then come next, quartzites, often finely *arkose*—the Mount Lofty quartzite is about 1,000 feet thick. Several limestones occur in this lower series, some of which are very *cherty*; others, relatively pure, and make good cement. At the base of the series there are grits, often

* E. C. Andrews, Cobar Copper and Gold Field, p. 188. † D. Mawson.
‡ W. Howchin.

felspathic, arkose grits, and conglomerates. These lower beds are often greatly sheared, and in places the pebbles are flattened out like pancakes, and finally pass into horizontal quartz veins.

"Your description* seems to tally very well with our Cambrian.

"Of course the local condition of thrust and metamorphic action will give a special facies to the beds in different localities. A very prevalent feature of our basal beds of Cambrian is in the presence of *clastic ilmenite,* derived from the pre-Cambrian floors on which they rest. False-bedding is also a very common feature."

The characteristic cross-bedding of the Canbelego Series is in harmony with the knowledge that Cambrian sediments are commonly cross-bedded. The presence of highly metamorphosed conglomerates in the Cobar Series somewhat similar to those known to be of definite Cambrian age in South Australia and those provisionally referred to the pre-Cambrian in the Kalgoorlie area,† is also interesting in this connection. So also the massive and altered quartzites and the coloured slates of the district are suggestive, read in conjunction with the account of the beds of known Cambrian age west of the Darling River. The absence of limestones and glacial beds in the Cobar and Canbelego Districts must, however, not be lost sight of in any discussion as to their age, although in such an area of aggradation it would be easily possible for such rocks as the limestones, and doubtless also the glacial beds, even if present, to be almost invisible at the surface.

The study of the lithology of the district, therefore, in the light of our knowledge of Silurian, Ordovician, and Cambrian lithology, and the history of orogenic movements in New South Wales, Victoria, and South Australia, suggests that the Cobar, Canbelego, and allied series are pre-Silurian, and possibly Cambro-Ordovician in age.

This large geological exposure appears to possess a general N.N.W. strike, and it is most probably closely related to the great belts of altered rocks occurring in the Orange Plains, Wagga, and Albury districts.

The Girilambone Series (Pre-Silurian?).

This assemblage of rocks evidently forms a portion of the same great group to which the Cobar and Canbelego Series belong. The main points of difference in the Girilambone and Canbelego rock characters are the greater metamorphism of the Girilambone types, and the more characteristic presence of altered massive quartzites in the Girilambone Group; nevertheless, although these points of variation exist, it has been considered advisable to provisonally classify both groups as belonging to the same great period of sedimentation.

The Ballast and Weltie Series (Silurian).

General Character and Distribution.

Cherts, conglomerates, sandstones, shales, and claystones are included in the series of this name, and the arrangement is approximately meridional. The Canbelego Series forms a long central mass flanked both east and west

*That is, of the sheared and distorted conglomerates, the "augen" sandstones, often schistose and arkose, the purple, red, and yellow slates, the schistose and puckered sandstones characteristically cross-bedded, the phyilites and the massive altered quartzites of Girilambone, Canbelego and Cobar.

†The Mining Geology of the Kanowna Main Reef Line, by T. Blatchford, B.A., and J. T. Jutson, pp. 19-22, with figures.

(*a*) Weathering along tiny joints in radiolarian chert from Ballast Series, Canbelego District. The shaded portions represent replacements of grey chert by reddish iron oxide.

(*b*) Puckered Sandstone and Claystone in Railway Cutting, about 4 miles west of Mount Boppy Railway Station.

by the Ballast members. Along the Cobar-Canbelego road, the series outcrops between the 3 and 8 mile pegs, while along the same road, but east of Canbelego, they occur between the 31 and 37½ mile pegs. The strike is a little west of north, and the series occurs at Florida Trigonometrical Station, 6 miles north of Florida railway station, on Sussex and Burramugga stations, still further to the north-west, and they may be traced for many miles to the south of the railway line. In the western outcrop the series may be seen at the Royal George, the Lucknow, the Wild Wave, and Leslie Mines, while to the south of the railway line it has not been traced for any but short distances, although it doubtless has a great extension in that direction.

Detailed Descriptions.

Conglomerates.—On the western outcrop of the Ballast Series, and at a distance of about 6 miles north of Florida railway station, a rugged hill series of about 150 feet in height above the level of the plain breaks the general level of the Cobar Plain. The occurrence is of the nature of a number of discontinuous ridges totalling about 4 miles in length. These ridges are covered with Brown Mallee and Currawong, and are composed of powerful conglomerates alternating with beds of sandstone, quartzite, cherts, and allied rocks.

The general strike is about N. 10° W., and S. 10° E., and the dip, although exhibiting great local variations, has an average value of about 60 degrees in a westerly direction.

The eastern members of the belt are not so coarse in texture as the western ones, and moreover, the coarser pebbles exhibit more signs of alteration than the less coarsely-textured belts. This was noticeable also in the Drysdale conglomerates to the north-west. Some of the more finely-textured beds might almost be described as coarse grits. In these the pebbles are frequently flattish, discoidal, and subangular. Very rarely are the pebbles at all spherical in appearance. The cement consists of argillaceous sandstone, greenish-grey in colour. The individual pebbles appear to consist mostly of whitish quartzite and quartzitic sandstone. The pebbles in the western bed adjoining the sediments just described are large, attaining diameters ranging from 2 to 24 inches. The material is of quartzite in the main. Many individuals are subangular, and many are faulted and sheared, as in the Mallee Tank and Bee Mountain occurrences.*

Very little elongation of pebbles was noted, and in this particular the conglomerates are in marked contrast to the occurrences of Drysdale, Restdown, Dijou, and the Rookery. Bedding planes are pronounced, whereas in the Dijou, Drysdale, Rookery, Nurri, and Restdown occurrences these divisional planes can be made out only with the greatest difficulty. Only slight traces of schistosity are observable in the sediments. Nevertheless conglomerates very similar to the Florida example are to be found at the Wild Wave, the Lucknow, and the Royal George Mines, lying within the western outcrop of the Ballast Series. In the latter outcrops, however, the conglomerate pebbles evidence much less signs of alteration than do those of the Florida Trigonometrical Station.

Cherts.—Sediments of this nature have a wide distribution within the area occupied by the Ballast Series, and the name of this sedimentary

* Cobar Copper and Gold Field, Part I, 1911. Plate XV, Nos. 2 and 3.

division of rocks has been derived from the fact that the ballast for the railway lines in the Cobar district is obtained from the cherts. Fig. 1 (*a*) illustrates the method of their occurrence in the Government Ballast Quarry or pit near the 36-mile peg along the Cobar-Nyngan road.

The main points of interest attaching to this group of sediments are:—

(1) The intimate association of the Ballast Series with the Florida Porphyries to the west, the porphyries appearing as lava flows separating the Canbelego Series from the cherts and associated rocks.
(2) The strong crumpling movement evidenced by a study of railway excavations.
(3) The perfect state of preservation of the bedding planes.
(4) The thinness of the individual beds of chert.
(5) The absence of decided metamorphism in the beds. This is suggested, indeed, by the intimate association of cherts, well-bedded, with sandy shales and claystones.

One of the points noted by the observer upon entering the large Ballast Pit belonging to the Railway Commissioners is the lack of alteration apparent in the sediments as suggested by the well-marked, but contorted bedding planes, and the absence of cleavage in the associated shale and claystone beds. This alone is strongly suggestive of the formation of the cherts as direct products of sedimentation, for if great masses of thinly-bedded sediments, such as those under consideration, had been altered to cherts, at a period subsequent to sedimentation it is strange that neither the bedding planes have been at all obscured nor have the thin and weak shale beds been silicified or otherwise indurated.

The bedding planes of the cherts show the usual wavy or undulatory surfaces so commonly seen, on such divisional surfaces, in regions of highly-crumpled rocks. The texture is homogeneous, the colour reddish, brown, and yellowish upon the weathered portions and the ordinary flint-grey on the unweathered portions. Curious weathering effects along joints are to be observed. (Plate VII (*a*).)

In thin sections under the lens a great number of small round bodies are easily discernible, and these are highly suggestive of radiolarian casts. Professor T. W. E. David, Mr. W. S. Dun, and Mr. W. G. Card have examined specimens of these rocks and have pronounced them to be radiolarian cherts.

These cherts evidently represent the eastern limb of a fold of which the Weltie Beds form the western limb, and the formation of the latter also by the accumulation of radiolarian casts may thus be inferred from a study of the Ballast cherts. In the Cobar report the probable origin of the Weltie cherts was referred to as a form of organic precipitate in the absence of definite radiolarian remains (p. 36).

It is interesting to note that the Ballast cherts are associated with porphyries, an assay of one of which yields 5 per cent. of soda. Mr. G. W. Card has called the attention of the writer in this connection to the papers of Dewey and Flett on British Pillow Lavas, and of W. N. Benson on Spilitic lavas in New England. Briefly, these authors show that Spilitic Lavas are characteristic of areas of continuous off-shore subsidence, and are often intimately associated with basic intrusions. Benson cites the

Western New England areas of New South Wales as having spilites in association with radiolarian cherts and sediments formed under comparatively shallow conditions.

Sandstones, Shales, and Claystones.

These sediments are highly folded, but do not bear evidence of considerable change. The sandstones are fine to medium in texture, the bedding planes are well preserved, cross-bedding is not so prominent a feature as in the Canbelego Series, and puckering is practically unknown. Eye or "augen" structures are rare. A decided proportion of argillaceous material is present. (Plate VI.)

The shales show no signs of cleavage and their bedding planes are not obscured although set very closely together.

Similarly for the claystones. The prevailing colours of these sediments at the surface are white, yellow, brown, grey, pink, and reddish, the lighter colours decidedly predominating.

Conditions of Deposition.

The majority of the sediments under consideration being of fine to medium texture with the presence, however, of one wide belt, if not more, of coarse and medium conglomerate, points to conditions of deposition somewhat similar to those of the Canbelego Series. Shore-lines are indicated both east and west of Canbelego by reason of the powerful beds of conglomerate. Sedimentation in shallow waters is suggested with variable positions of land and sea at various times. The cherts are due to organic precipitates as evidenced by the abundance of peculiar forms present, strongly suggestive of radiolarian casts, and the general absence of decided metamorphic phenomena in the associated sandstones, claystones, and shales.

Age and Correlation.

The Weltie and Ballast Series are classed as Silurian because limestones of that age occur in the Mallee Tank beds to the south of Cobar, and the general appearance of the latter is that of the Ballast and Weltie Series, with the exception of the chert beds. These well-bedded and blue limestones have been powerfully crumpled, but without recrystallisation. Limestones also of Silurian age at Restdown do not appear to have suffered much from metamorphism.

The Weltie and Ballast Series have been closely-folded within a metamorphic basement of pre-Silurian rock types.

In the Cobar Report, which forms Part I of this series, the schistose rocks, together with the Weltie and Mallee Tank Series, were classed provisionally as Silurian sediments, because of the limitation of the Cobar Series to a zone of moderate width which it was considered might have been caused by zones of crushing. The occurrence of wide areas of much-altered rocks at Girilambone and other localities, however, suggests that this explanation by the assumption of differential metamorphism of Silurian sediments was not as simple as that which refers the rocks of the district to various periods of sedimentation.

The Mount Boppy Series (Devonian).

General Character and Distribution.

The rocks included in this division occur mainly as outliers on a basement formed by the Canbelego and Ballast Series. The dips are usually gentle, although here and there the inclination of the beds to the horizon is decidedly high. This steepening of the dips is due to the compression over very limited areas of the Mount Boppy Series within the older basement.

The sediments comprise massive conglomerates, sandstones, quartzites, and weak masses of chocolate, or reddish, material, apparently of tuffaceous origin.

Detailed Descriptions.

The Conglomerates.—These are of the massive variety, and they form the basal members of the series. The dips are gentle, and the general appearance is that of beds of undulating dip underlain at shallow depths by the strongly-compressed members of the Canbelego Series. The general relations are indicated on the main section taken across the field. The pebble beds occur in two or three distinct layers, alternating with sandstones, quartzites, and tuffaceous material. In the Canbelego area the basal member consists of a strong bed of conglomerate composed of pebbles of white or greyish translucent quartz, and of fragments of the schist basement upon which it rests. This is seen particularly well at Mount Boppy itself. South of Mount Boppy, the Boppy Series are frequently represented by thin sheets of the basal conglomerate overlying a schistose basement, or it may be that the Boppy Series are represented only by large heaps of isolated fragments or long, narrow lines of this basal conglomerate, lying loosely upon the slate and schistose basement. In such case the conglomerate fragments have persisted simply because of their great resistance to the agencies of erosion, and as the underlying schist is worn away the conglomerate masses simply settle down gradually on to the older rock. Such exposures occur almost without exception on the low ridges.

The pebbles are subangular rather than rounded. This lack of sphericity applies alike to the quartz and the schistose fragments. The quartz pebbles appear to be of material similar to that occurring as quartz veins, or masses, in the Canbelego complex. The size of the pebbles varies from half an inch to as much as 5 or 6 inches in diameter. The cementing material is of quartzitic grit, or sandstone, with which a certain amount of argillaceous material is associated.

Mount Boppy consists mainly of the conglomerates and their associates. The peculiar appearance of the surface of the summit is due to the folding of the upper bed of conglomerate. This bed has been warped into a syncline, the limbs of which lie almost horizonally, at the southern end of the hill, but which are inclined towards each other to the north at an increasing angle. The maximum dip of the trough is a few degrees to the north, and the maximum inclination to each other of the synclinal limbs is about 35°. The overlying beds have been removed by the agencies of erosion.

The Quartzites and Sandstones.

These, in common with the sandstones, form very resistant structures which in place pass gradually into conglomerates. The texture is generally fine to medium, and the sand grains are not well rounded. The colours are prevailingly light-greyish. It is probable that the so-called quartzites are mainly quartzitic sandstones. For example, the fracture is

neither conchoidal nor even sub-conchoidal, and it does not pass through sand grains and cement indifferently.

Tuffs and Shales.—These comprise certain thin beds containing marine shells of indeterminate nature. The texture is fine, the colour dark-grey to red, brown, and chocolate. Their stratigraphical position is near the basal conglomerates, and they constitute a decided weakness in the otherwise powerful series.

Thickness of Beds.—The outliers of the Boppy Series are mere remnants of a once continuous, and thick, mass of sediments stretching from the east of Boppy northwards to the Bogan and Darling, west to the Darling, and south to a point beyond the Lachlan River.

The explanation of this reduction of the Boppy Series to the status of mere outliers in the district under consideration is to found in the slight folding movement suffered by the series and the relative weakness of the sediments overlying the basal conglomerates and quartzites.

The Boppy Series was folded gently, and its members were not deeply buried below the level of erosion by such types of folding, thus during the periods of subsequent denudation the Boppy Series were especially exposed to the agencies of erosion, with the result that in time only remnants were left in place, such as were most favourably situated as regards preservation, and such as were the most resistant to erosive activities.

At the most only about several hundred feet in thickness of sediments belonging to this Series are to be found at Canbelego, but rocks apparently belonging to the same group attain a great thickness to the west of Cobar, where they have been folded below the zone of erosion.

Conditions of deposition.—The widespread presence of the conglomerates and the arrangement of the thicker and more coarsely-textured beds, as in the neighbourhood of Canbelego, and at Kerrigundi, Wittagoona, Barnato, and other places from 60 to 70 miles west of Canbelego, suggests the presence of a shallow sea with retreating shore-line, and the building of lines of dense conglomerate and sandstone during periods of halt of the shore-line.

The tuffaceous material suggests the redistribution of volcanic matter by currents in a shallow sea.

It is probable that the tuffaceous material was abundantly developed in the Series, but has now been removed in great measure.

Age and Correlation.—The Boppy Series are considered to be Devonian, because of their lithological characters, and because Devonian marine sediments, apparently the same as the Boppy Series, have been recorded* from Hermitage Plains to the north of Canbelego.

The fossils were collected by Mr. J. E. Carne and Mr. E. F. Johnston at different times, and have been referred by Mr. W. S. Dun to the genera Spirifera (cf. crispa), Rynchonella, Pterinea, Modiomorpha, and Panenka.

Owing to the strong local folding in the large Cobar district, and to a general absence of well-preserved fossils, it has been found impossible at the present time to ascertain the exact position of the junction of Devonian and older sediments in certain localities. This does not apply to the Canbelego district, where powerful basal conglomerates, and sandstones, rest upon a basement of schists, but at Nymagee and in areas west of Cobar, the problem is beset with difficulties which can be cleared up only by the help of fossil evidence.

* Annual Report, 1903, p. 171.

Field Notes.

General Description.—The rocks of this class fall under the head of acid porphyries and intermediate types.

Distribution.—The arrangement of the porphyries coincides with the main strike of the associated sediments, namely N. and S. to N.N.W. and S.S.E., and their extension in length is considerable, but interrupted, along a zone extending from a point 1 mile north of Florida railway station to one many miles south of Bobadah; in all, a distance possibly exceeding 100 miles.

The porphyry outcrops, however, are discontinuous, the longest exposure probably not exceeding 12 or 15 miles, and the gaps separating the exposures having a maximum length of 20 miles.

The distribution of the more basic types is in the form of lines rarely exceeding 10 or 20 chains in length. One, however, a hornblendite at Honeybugle, has a length exceeding 1 mile. These also appear to follow the general strike of the associated sediments. Such types lie both west and east of the porphyries at Canbelego.

Nature of Occurrences.

Porphyries.—The width of the exposures rarely exceed 2 miles, and this alone suggests that the occurrences are either contemporaneous flows in the Palæozoic, or that they are intrusives along a great plane or zone of weakness in the Palæozoic sediments.

The northern occurrence is from 12 to 13 miles in length, with a maximum width of from 2 to 3 miles. The long collinear ridges known as Nos. 1, 2, and 3 hills, are composed of red and green felspar, and quartz porphyries, homogeneous in appearance, while the western foothills of the ridges consist of banded and brecciated rhyolites. Spherulitic rhyolites possibly occur at No. 3 hill, because the prospectors speak of a band of conglomerate or pudding-stone in the hill. The hill is composed of porphyry, but the writer failed to detect the so-called "pudding-stone"; nevertheless, it is highly probable that prospecting operations have here exposed a small band or patch of spherulitic rhyolites on the hillside, but which has been concealed subsequently owing to the actions of storms. The eastern members of the series also contain fine examples of banding.

The porphyry mass sends off an offshoot towards the Mount Boppy Mines, and a dyke appears to exist south of the Boppy workings.

The general weathering of this large porphyry exposure is similar to that of a well-jointed granite.

At Restdown Copper Mine the porphyry again outcrops over an area of about 40 acres, and here its general appearance, and its isolation, are suggestive of a "pipe" origin.

At the 15-mile peg on the Nymagee-Hermidale road a series of rugged hills rise abruptly from the plain, and continue thence, with breaks, to the south of Bobadah. The rock types are agglomerate, breccias, tuffs and lavas of rhyolitic or siliceous porphyry nature. Flow structures are fairly common.

The section revealed by the mining workings at the No. 51 Block, along the Burra Burra line of lode, shows the porphyry as having a very steep inclination to the horizon. The relation of porphyry and schists could not be ascertained in the small exposures accessible. The steep dip of the

porphyry may be explained by the compression which affected the associated Palæozoic sediments. It does not demand the assumption of an intrusive origin.

On the other hand, the abundant presence of tuffs and breccias, the flow structures in the porphyries, and the lack of holocrystalline structure in the porphyries, coupled with the fact of their great width, namely, from 1 to 3 miles, suggest a volcanic origin for these interesting rocks.

The hornblende norite and the diorites.—These have a very limited distribution, being confined, apparently, to a belt of country not exceeding 10 miles in length by 6 miles in width, and lying to the west of the siliceous porphyries. The longest exposure does not exceed 10 chains in length nor 5 chains in width. The occurrences may be classified either as "pipes" or dykes.

Age.—The porphyries have been found in association with the older sediments of the field. Near Canbelego itself they lie at the junction of the Ballast and Canbelego Series, and from the great amount of banded rhyolites and coarse tuffs associated with them they appear to be lavas. At the Restdown Mines they appear to be of the nature of a pipe in sediments of Lower Palæozoic age. Near the Queen Bee Mountain the occurrences are of the nature of "pipes" in schistose sandstones.

The porphyries have not been seen in association with the Devonian sediments in the Canbelego district, and they appear to be older than sediments of this age.

Their age, for the present, may be assigned to the Silurian.

The age of the basic rocks associated with the Canbelego Copper Lode, and those lying south of the Boppy, Broken Hill, is doubtful, but may be either Silurian or pre-Silurian. They appear to have suffered considerably from the agencies of metamorphism.

Petrographical Notes.

By G. W. Card, A.R.S.M.,

Curator, Mining Museum.

With Analyses by J. C. H. Mingaye, F.I.C., and H. P. White, F.C.S.

The Florida rhyolite series comprises a succession of porphyries and felsites with tuffs. They are of a prevailing greenish-grey colour, mottled with white felspar, but may be red. Felspar is the dominant phenocryst, generally in actual quantity, and always by reason of the inconspicuousness of the quartz for want of colour contrast. The felspar phenocrysts are rhomboidal in form, and generally opaque, white in colour, but may be pink, and they impart a handsome appearance to the polished rock. They usually range up to 3 mm. in length, but may attain 5 mm., or even more. Megascopically the groundmass is structureless, except that one or two specimens are fluxional, and split more or less along the planes of flow. Silicification has taken place in some cases, and the rock is then very hard, and capable of taking good polish.

Under the microscope, it is clear that the groundmass represents devitrified glass. While it is now thoroughly felsitic, or even microcrystalline, original structures, such as perlitic cracks, fluxion, and possibly microspherulites, can be detected in some of the specimens. The phenocrysts are usually greatly corroded and deeply embayed by the groundmass, some of them being completely eaten through.

Felspar is the predominant mineral, with much quartz, a little biotite, and very rarely apatite. The felspar is considerably clouded. Both orthoclase and plagioclase are present, the latter in very considerable proportion. Orthoclase is in large part perthitic or micro-perthitic. The extinction angles of the plagioclase are usually higher than those of oligoclase, and approximate to albite. This, combined with the low index of refraction, would indicate the presence of albite among the phenocrysts, but a more calcic felspar must be represented to some extent. Composition zoning was noticed occasionally. Silicification has clearly taken place in some instances, and has probably accompanied the process of devitrification throughout. The occasional distribution of scales of green pigment through the groundmass may also be regarded as due to secondary action.

The chemical composition of the magma is indicated by complete analyses of three specimens from different positions on No. 3 hill, and the alkalinity was further investigated by a determination of soda and potash in a series taken right across the outcrops. Owing to silicification, the composition of the rocks must have been modified since consolidation, and the total silica may perhaps be higher than in the original magma.

Analyses.

	A.	B.	C.
SiO_2 ...	73·33	77·39	77·08
	1·222	1·289	1·285
AL_2O_3 ...	12·43	9 50	11 59
	·122	·093	·114
Fe_2O_3 ...	0·10	0·30	0·20
	·001	·002	·001
FeO ...	2·43	1 08	1 44
	·033	·015	·019
MgO ...	0·59	0·17	0 64
	·015	·004	·160
CaO ...	0·98	0·42	0·84
	·017	·007	·150
Na_2O ...	2·71	1·72	4·63
	·044	·027	·074
K_2O ...	5·66	6·54	1·57
	·060	·069	·017
H_2O+	1·41	2·14	1·04
H_2O-	0·09	0·08	0·24
CO_2 ...	trace	trace	0·48
TiO_2 ...	0·23	0·45	0·35
	·003	·005	·004
ZrO_2 ...	none	none	0·02
P_2O_5 ...	0·11	0·06	0·01
V_2O_5 ...	none	none	none
SO_3 ...	none	none	none
CL ...	trace	trace	none
S ...	none	none	0·05 (FeS_2)
Cr_2O_3 ...	none	none	none
NiO ...	none	none	none
MnO ...	trace	trace	0·13
			·001
BaO ...	0·06	0·04	0·04
SrO ...	none	none	Spect. trace
Li_2O ...	none	none	none
	100·13	99·89	100·35
Specific gravity ...	2·648	2·625	2·633

A.—Analysis of rhyolite from No. 3 Hill, Florida. Analyst, H. P. White.

B.— ,, ,, ,, ,, (non-porphyritic phase). Analyst, H. P. White.

C.—Analysis of soda rhyolite from No. 3 Hill, Florida (from west slope of hill) Analyst, J. C. H. Mingaye.

The Norms.

	A.	B.	C.
Quartz	31·2	42·5	40·8
Orthoclase	33·4	38·4	9·4
Albite	23·1	12·6	38·8
Anorthite	4·7	.....	3·9
Corundum	0 1	.....	0·9
Acmite	.....	0 9	.....
Sodium metasilicate	.....	0·1	.....
Diopside	.....	1·7	.....
Hypersthene	5·1	1·7	3·6
Magnetite	0·2	. ...	0·2
Ilmenite	0·5	0·8	0·6

Magmatic Name :—
A. Toscanose.
B. Magdeburgose.
C. Alsbachose.

Table of alkalinity of a series of samples taken across the rhyolite outcrops:—

No.	Potash.	Soda.	Total alkalies.
1	4·50	4·34	8·84
2	6·55	2·92	9·47
3	5·20	2·48	7·68
4	5·26	3·30	8·56
5	5·22	3·11	8·33
8	3·45	3·26	6·71
9	5·43	2·11	7·54
10	5 28	2·51	7·79
11	5·36	1·82	7·18
12	8·15	1·02	9·17
13	6·19	1·50	7·69
14	6 55	1·72	8·27
15	8·23	1·23	9·46
16	5·17	1·80	6·97
17	2·32	3·87	6·19
18	3·34	3·93	7·27
19	3·89	3·61	7·50
20	4·31	2·90	7·21

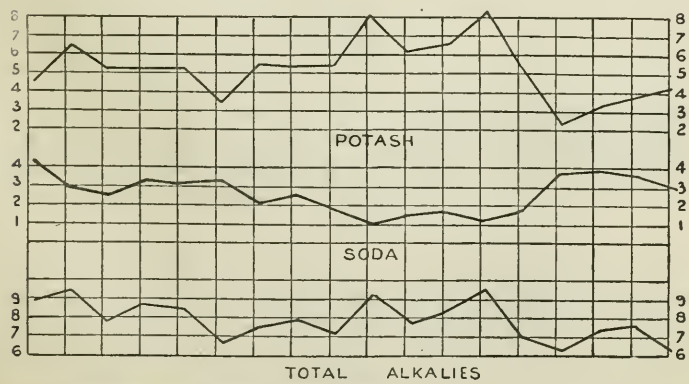


Fig. 3.—Diagram showing the variation in alkalinity of the rhyolite.

These analyses show that the Florida rhyolite series is distinctly alkaline. Potash is usually predominating, but in a few instances, and notably in one of the complete analyses from No. 3 hill, soda is in excess. Mineralogically, this is expressed in the presence of albite. The varying nature of the alkalinity, and the occurrence of albite, suggests the possibility that soda may have been partially introduced into the rock series as a phase of alteration. Moreover, this possibility, in conjunction with the occurrence of radiolarian cherts in the district, offers some analogy to the spilite suits of rocks, upon which stress is now laid.

The existence of a certain amount of strain-shadowing in the quartz phenocrysts, and occasional shattering, may point to a moderate degree of dynamic action since consolidation, but this could have occurred during flow.

The Florida rhyolite series in detail is briefly described in the following tabular statement, beginning with the No. 3 hill rock, and continuing with the series of specimens taken across the outcrops. Of the whole, two, or possibly, three, are tuffs.

Megascopic.	*Microscopic.*
No. 3 Hill Summit.—A beautiful porphyry, with abundant phenocrysts of pink and red felspar, and quartz in a dark green matrix. The phenocrysts approximately equal the groundmass in total volume, and vary in size up to 4 or 5 cm.	Groundmass felsitic. The quartz phenocrysts are typically corroded, and show some strain-shadowing. Those of felspar comprise micro-perthitic, orthoclase, and a plagioclase, with extinctions greater than those of oligoclase; all are much coloured. A ferro-magnesian mineral is represented by wisps of dark-green secondary material.
No. 3 Hill Summit.—Greenish black, platy porphyry, mottled with white felspar. Otherwise like red porphyry just described.	Groundmass felsitic and fluxional. Mineralogically similar to the red porphyry. Apatite present.
No. 3 Hill.—Light grey porphyry, with inconspicuous phenocrysts.	Groundmass micro-crystalline. Quartz corroded, shattered, and under strain. Orthoclase, microperthite, plagioclase as described above. Apatite present.
1. Light grey aphanite. Very numerous phenocrysts of flesh-coloured felspar, with some quartz.	Groundmass micro-crystalline. Felspar phenocrysts are in part clustered. They comprise both orthoclase and plagioclase, and albite is undoubtedly present.
2. A creamy weathered specimen, markedly fluxional, and splitting along the lines planes of flow. Light and dark banding.	Although completely devitrified, the groundmass shows perlitic structure very distinctly. It is silicified and traversed by quartz veins. Both orthoclase and plagioclase present, some of the latter having extinction angles as albite.

Megascopic.	*Microscopic.*
3. Light greenish grey aphanite, rudely banded on the weathered surface. Phenocrysts of flesh-coloured felspar are scattered rather sparsely, with some of quartz.	Groundmass crypto-crystalline. Banding indicated by a line of coloration. Some silicification. Orthoclase and plagioclase present.
4. 5. Light greenish grey aphanite, mottled with white spots.	Groundmass felsitic to crypto-crystalline. The phenocrysts comprise quartz orthoclase and plagioclase, and are not at all crowded. Albite may be present, and there is some apatite.
6. Perfectly aphanitic. Yellow.	Groundmass micro-felsitic. Nothing is decipherable, save a tiny felspar very rarely. Veined with secondary silica.
7. A creamy quartz-tuff. Abundance angular grains of quartz are set in a flinty base. The fragments range up to 1 mm.	Angular fragments of quartz, of all shapes and sizes, comprise about one-half the rock, with finely clastic material making up the rest.
8. Light grey felspar-porphyry. Felspar phenocrysts pale flesh-coloured, aggregated.	Groundmass micro-crystalline, and showing clear indications of former fluxion. Apatite is present, and a granitic xenolith detected.
9. A magnificent porphyry, with numerous rhomboidal phenocrysts of red and creamy felspar in a grey base. The phenocrysts nearly equal the base in total volume, and attain 5 mm. in length. (*See* analysis of a similar rock from No. 3 Hill.)	Groundmass felsitic. Some indications of original banding, traced by lines of secondary silica.
10. Felspar-Porphyry, with abundant rhomboidal phenocrysts of creamy felspar in a greenish grey groundmass. Phenocrysts up to 5 mm. in length, and nearly equal to the groundmass in total amount. The rock is platy, and slightly calcareous.	Groundmass felsitic. The felspar is in part plagioclase, and some of it has the extinction of albite. Lamellæ of calcite occur in some of the felspar. The quartz phenocrysts are shattered (with infilling along the cracks), and show some strain-shadowing.
11. A platy, jointed, buff-coloured aphanite, with quartz just discernible under a lens.	Somewhat tuffaceous in appearance. Abundant angular fragments of quartz, and some of felspar, in a felsitic groundmass. Here and there are shattered or corroded phenocrysts of felspar.

Megascopic.	*Microscopic.*
12. Greenish grey aphanite, mottled with an abundance of opaque white, rhomboidal phenocrysts of felspar, up to 1 cm. in length. Much quartz. The rock is calcareous, and contains specks of metallic sulphides.	Groundmass micro-crystalline, and more or less silicified. The orthoclase phenocrysts are perthitic, and show lamellæ of calcite.
13. Similar to 12.	Part of the plagioclase may be albite. It is shattered, and the twin lamellæ are crumbled. There is some calcification of the felspar.
14. Similar to 12.	Groundmass felsitic, and sprinkled with green pigment scales. The felspar is crypto-perthitic. Some chlorite, after biotite.
15. Pyritized and silicified.	
16. Volcanic ash, the clastic character being just evident under a lens.	Angular fragments mainly quartz, with an irresolvable base.
17. Contact of porphyry similar to 12, with tuff. The phenocrysts are above the average size, ranging to 7 to 8 mm.	Shattered phenocrysts of quartz and felspar, in a devitrified groundmass, which may perhaps be a pumice ash, in which case the whole rock will be tuffaceous.
18. Partially silicified porphyry. Grey and white in colour, with chloritic patches.	
19. Similar to 18.	Groundmass micro-crystalline.
20. Grey and white quartz-felsite.	Groundmass thoroughly micro-crystalline. Crowded with phenocrysts of quartz and felspar, orthoclase, with oligoclase, or albite.

(8628.) Quartzite, pebbles from conglomerate at Florida Trig. Station.

(8683.) Quartz-Schist. Boppy Broken Hill, Canbelego.

Grey, indistinctly fissile, parting faces micaceous. Under the microscope, the quartz grains show strain-shadowing. There is much orientated mica, and crypto-crystalline interstitial matter. The original nature of this rock is not clear.

(8731.) Schistose argillaceous sandstone. Boppy Broken Hill, Canbelego.

A rudely fissile rock; the sandy nature is just evident under a lens. The puckering of the rock is clearly indicated by a quartz vein. Under the microscope, the schistosity is traceable to brown-stained layers of mica. These mica streaks do not cross the puckered vein, which would thus seem to be of later date. The quartz grains show slight strain-shadowing, and are separated by feebly polarizing material.

(8670.) Tuff, western foot of No. 3 hill, Canbelego.

A greenish grey, jointed, rather compact rock. The weathered surface shows long drawn-out particles of creamy quartz-felsite, which may have been injected. Under the microscope, the tuff consists of irregular fragments of quartz-felsite in a groundmass of quartz grains, shattered felspar, and cryto-crystalline material. Some strain-shadowing is present.

(8680.) Volcanic ash, western foot of No. 3 hill, Canbelego.

A red banded quartzite-like rock, the clastic character of which is evident under a lens. Under the microscope it consists of angular quartz—unorientated save for rude banding—with some orthoclase. Crypto-crystalline material lies between the grains, and there is slight strain-shadowing.

(8665.) Crushed diorite, Shango shaft, Canbelego.

Pale green, soft, and schistose. Under the microscope it consists essentially of plagioclase, hornblende, and chlorite. The plagioclase is in an early stage of crushing, and shows mortar structure. The hornblende is pale green, and altering into chlorite it may perhaps be inferred from general knowledge of such rocks that the hornblende is secondary, but there is no direct proof of this. This rock is, at present, mineralogically distinct from the norite found in the vicinity, but the distinction may be due to differential metamorphism in the two rock types.

Norites of Canbelego.

(8726.) Hornblende-Norites, 2 miles S. 20° E. of Boppy Broken Hill Mine, Canbelego.

Pale greenish grey in colour, very tough, but soft and unctuous under the knife. Bronzite is conspicuous. The greatest alteration, and the presence of talc everywhere, renders description difficult. Bronzite, diopside, and hornblende are closely intergrown, the hornblende being probably secondary. The ferro-magnesium minerals are passing into talc, and felspar is dusky or opaque. That the rhombic pyroxene is bronzite is indicated by the high percentage of ferrous oxide present, as shown by the analysis following:—

Analysis.

SiO_2	46·66	TiO_2	0·65
	·778		·008
Al_2O_3	18·50	ZrO_2	none
	·181	P_2O_5	0·07
Fe_2O_3	0·77	V_2O_5	0·01
	·005	SO_3	none
FeO	6·93	Cl	0·03
	·096	FeS_2	0·03
MgO	9·76	Cr_2O_3	0·02
	·244	NiO	0·03
CaO	9·88	MnO	0·22
	·177	BaO	0·02
Na_2O	1·44	SrO	none
	·023	Li_2O	none
K_2O	0·27		
	·003		100·46
H_2O+	4·88		
H_2O-	0·20	Specific gravity	3·001
CO_2	0.09		

The Norms.

Orthoclase	1·7
Albite	12·0
Anorthite	43·1
Diopside	5·0
Hypersthene	24·9
Olivine	5·7
Magnetite	1·2
Ilmenite	1·2

Magmatic name—Auvergnose.

Analyst, J. C. H. Mingaye.

Rocks of Neighbouring Areas.

Gilgunnia Rocks.

(8467.) Quartz-Felspar-Porphyry. 2 miles west of Gilgunnia. Colour, light grey, weathering red. Fracture hackly. Phenocrysts abundant, comprising opaque white felspar and much quartz. Felspar phenocrysts range up to 1 inch in length; those of quartz are smaller.

Under the microscope, the groundmass is felsitic, and perlitic markings are distinct. The quartz phenocrysts are, on the whole, not greatly corroded, and are under great strain. Felspar is not much altered, but some of the crystals are badly shattered. It is plagioclase, perhaps an acid labradorite. This rock is evidently a devitrified glass.

(8468.) Quartz-Felspar-Porphyry. North Peak, 600 feet above base. A grey rock, breaking with an even to sub-conchoidal fracture. Phenocrysts are very numerous, comprising much quartz, and opaque white felspar ranging up to ¾ inch in length.

Under the microscope, the groundmass is crypto-crystalline. Quartz is corroded and cracked, and every phenocryst is surrounded by a reaction rim, lighter in colour than the general groundmass. Felspar also shows multiple twinning, but is much altered.

(8469.) Altered Diorite. Close to North Peak. A greenish-black crystalline rock, of which little can be made megascopically.

Under the microscope, it consists largely of plagioclase felspar, which is much altered. Iron ores are scattered throughout, and there is much development of isotropic green material.

Budgery.

(8460.) Chloritic Schist. 300-feet level South Budgery shaft.

Under the microscope shattered felspar is seen, which appears to indicate that the schist was formed from the crushing of an igneous rock.

Nymagee.

(8456.) Pegmatite. 6-mile cutting, on Canbelego-road.

Pegmatite, composed of quartz, felspar, and muscovite. Under the microscope one of the two specimens shows much shattering, and some mylonization.

(8452.) Tourmaline-Granite. 8-mile cutting, on Canbelego-road.

Mount Hope Rocks.

(8453.) Felspar-Porphyry. Coan Downs Station.

Megascopically the rock shows a perfectly aphanitic black groundmass, with scattered phenocrysts of felspar.

Under the microscope, the groundmass is microlitic and fluxional. The felspar is plagioclastic.

(8470.) Quartz-Felspar-Porphyry. Coan Peak.

A light-grey groundmass, crowded with phenocrysts of opaque white felspar and of quartz. The felspar crystals range up to an inch in length.

Under the microscope, the groundmass is crypto-crystalline. Quartz is corroded, and not under strain. Felspar is much altered. Some of the larger phenocrysts are orthoclase, the others appear to be in part oligoclase.

(8471.) Coan Peak. Quartz-Felspar-Porphyry.

A dark-grey groundmass, crowded with phenocrysts of opaque white felspar and of quartz. The latter equal, or even exceed, the groundmass in aggregate volume.

Under the microscope, the quartz is corroded, and is much shattered and strained. Felspar is plagioclastic, and greatly altered. A good deal of chloritic matter is developed. Groundmass felsitic.

(8472.) Quartz-Felspar-Porphyry. Gingerambone Hill (Mount Hope).

A light-grey groundmass, thickly set with phenocrysts of opaque white felspar and of quartz. The felspar crystals range up to one-third of an inch in length. Fracture sub-even.

Under the microscope, quartz is corroded, cracked, and strained. Felspar is much altered. The groundmass is crypto-crystalline, and there is considerable development of green material.

STRUCTURE.

General Statement.

From a structural point of view the rocks in the Canbelego area may be divided broadly into two types, namely, a basal complex of intensely crumpled sediments and an overlying series whose members have only been affected to a minor degree by compressive agencies. The older complex, in turn, admits of a division into two groups both highly folded, so highly indeed that the folds are not only decidedly asymmetrical, but in places they appear to be almost recumbent, strongly suggestive of the existence of isoclinal folding and overthrust faulting. The occurrence of certain powerful quartzite beds in parallel groupings also suggest isoclinal folding. Of these older groups one appears to have suffered much more than the other from the forces of compression, the sediments having been highly puckered and converted into slates, phyllites, schists, and "augen" sandstones.

Ages of Folding.

The general appearance of the slates, phyllites, schists, and quartzites comprising the Canbelego and Girilambone Series is suggestive of a tectonic unit, as it is impossible to separate the series into two structural systems. If

the two series represent different periods of sedimentation, as is suggested by their variable textures and nature, nevertheless the metamorphism to which they have been subjected is of an order comparable in intensity.

Before dealing with the age of the folding of the Girilambone and Canbelego Series, it will be advisable to discuss that of the Ballast and Weltie Series. In this connection it is interesting to note that the crumpling to which the latter groups have been subjected was very severe, nevertheless, puckering and schistose forms are characteristically absent. Thus the limestones of the Rookery apparently belong to the same period of formation as the Weltie and Ballast Series, and the latter, therefore, may be set down as of Silurian age. It is almost certain, on the other hand, that if the ordinary blue limestone beds of the Rookery formation had been subjected to the metamorphic activities which resulted in the production of the Girilambone schists and quartzites, they would have been altered to marbles. The Forbes-Parkes area may be cited in this connection, where certain small patches of marbles are associated with slates, phyllites, and quartzites, reasonably considered to be of Ordovician age*, while the unaltered blue limestones in the vicinity, containing fossils of definite Silurian age are associated with cherts, claystones, sandstones, and shales.

Furthermore, the strongly-folded, but non-metamorphic, blue limestones of Silurian age at Restdown, 40 miles south-east of Cobar, are associated with claystones, sandstones, and other sediments which show little signs of alteration.

Examples of the differential stress and alteration to which Ordovician and Silurian sediments have been subjected in New South Wales and Victoria might also be brought forward in support of this view.

Thus in the Tallong area on the Shoalhaven River, in New South Wales, carbonaceous shales, quartzites, cherts, and slates of Ordovician age have been "intensely folded and crumpled."† "Their folded character, as compared with the simple tilting of the Silurian beds is additional evidence of the same fact." . . . "The Silurian rocks are tilted, but are not noticeably folded, while the Ordovician strata are crumpled into most extraordinary shapes."‡

At Parkes and Forbes a large exposure of Ordovician, and possibly, older sediments, are associated with cherts, claystones, sandstones, and limestones of Silurian age. The latter are gently folded only, but the associated slates, schists, and quartzites have been closely folded and puckered.§

Strongly-folded claystones and other sediments of Ordovician age have been recorded from Mandurama.‖

The Ordovician of the south-eastern portion of the State, on the Victorian border, are strongly folded,¶ but apparently not intensely so, neither have they been altered to schists.

Another outcrop of Ordovician sediments** comprising well-cleaved purple and green slates, graptolitic claystones, sandstones, quartzites, and siliceous slates occurs about 15 miles north of Goulburn. (These, however, are neither so intensely folded nor so altered as the Girilambone and Canbelego sediments.)

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* E. C. Andrews, Forbes-Parkes Gold-field, Mineral Resources, No. 13, Dept. Mines, N.S.W., pp. 20, 21.
† W. G. Woolnough, "General Geology of Marulan and Tallong." Proc. Linn. Soc., N.S.W., 1909, p. 784.
‡ *Ibid.*, p. 735. J. E. Carne, Mineral Resources, Dept. Mines, N.S.W., 1911, p. 344. § E. C. Andrews. Forbes-Parkes Gold-field, Mineral Resources, Dept. Mines, N.S.W., No. 13, pp. 20, 21. ‖ E. F. Pittman, Records, Geol. Survey N.S. Wales, 1900, VII, pp. 9–12. ¶ J. E. Carne, Annual Report, N.S. Wales, 1896, p. 101. ** J. E. Carne and E. C. Andrews, Annual Report, 1913, pp. 181, 182.

In other parts of New South Wales also, rocks believed to be of Ordovician age have been strongly crumpled and altered.

It appears reasonable, therefore, to place the folding of the Girilambone and Canbelego Series, provisionally, at the close of the Ordovician, and it is possible that both Ordovician and Cambrian sediments have been involved in this the great critical period of the Palæozoic in Eastern New South Wales.

The Silurian sediments of the Canbelego and Cobar areas are strongly folded, while the Devonian rocks have suffered much less from compressive activities. This suggests a strong folding of the Silurian prior to the deposition of the Devonian.

The absence of sediments of known Carboniferous age in the district suggests either that the Devonian sedimentation was closed by folding or that the folding took place during, or at the close, of the Carboniferous, but that no sedimentation occurred during the Carboniferous. This folding movement was peculiar, for, despite the fact that the beds were only folded gently, as a whole, nevertheless small patches of rock of Devonian age have been sharply compressed within the older sediments. The sections, accompanying the report, illustrate this point.

In this connection it is interesting to note that the Devonian sediments in the western areas of the State as a rule have been folded only in a minor degree with sharp compression over very small areas. The Devonian sediments of county Ashburnham may be cited in this connection.*

Sediments, however, which have been referred to the middle, or lower, Devonian, as at Murrumbidgee and Tamworth, have been strongly folded, but without the production of slaty and schistose structures.†

At Yalwal also, on the Shoalhaven River, the Devonian sediments have been strongly folded.

In the large area of the Canbelego district, it would thus appear that the sediments of pre-Silurian age were closely folded and puckered; that the masses thus raised were worn down by stream and wave action in part, and doubtless also in part, by sea transgression owing to vertical movements of land or sea; that on the masses of rock thus denuded the Silurian sediments were deposited; that these beds, in turn, had been strongly folded and denuded in turn; that Devonian beds had been deposited in certain large and low-lying areas in the older rock masses; and that this period of sedimentation had been closed, in turn, by the latest of the compressive movements indicated for this area.

The explanation of the phenomenon of the close folding of the Silurian and pre-Silurian sediments of the area is bound up, doubtless, with the fact that the sediments so closely compressed are of enormous thickness. This great thickness is suggested by the prevailingly high dips of the sediments and the great distances separating beds of similar appearance.

It appears to be a recognised principle that the greatest mashing of sediments generally occurs in the regions of pronounced deposition. Thus the Cambrian and Ordovician sediments of limited thickness in Colorado and the neighbouring regions have a disposition almost horizontal, while the great thicknesses of sediments contemporaneous or homotaxial with these, in the Appalachian region, have been much folded and altered. In England

*E. C. Andrews and M. Morrison, Cargo Gold-field, Mineral Resources, No. 19. †T. W. E. David, B.A., and E. F. Pittman, A.R.S.M., Quarterly Journal Geol. Science. L. F. Harper, Rec. Geol. Survey, N.S. Wales, 1909, Vol. IX, Pt. 1.

and Wales, as also in Western Europe, the Cambrian and Ordovician combined have an enormous thickness, and in these regions they are closely folded. Nevertheless in Eastern Europe, where Cambrian and Ordovician sediments do not total more than 200 feet in thickness, they still lie horizontally. The mashing of the great thicknesses of the earlier, and late, Tertiary sediments in the region of the Himalayas, and of Tertiary sediments in the region from the Pyrenees to the Himalayas and along the Pacific Coast of North America are other examples. The highly folded, and altered sediments, apparently of pre-Silurian age, in the Canbelego and Cobar districts, furnish still another example. The principle might be illustrated by other examples.

A note of caution should be sounded, however, at this stage. The inference is not that *all* great thicknesses of sediments must be strongly mashed, but rather that all great thicknesses of sediments, *which are the product of rapid accumulation,* say, during periods of time relatively short, such as the Cambro-Ordovician, the Silurian, the Devonian, the Tertiary, would be found to have been strongly mashed. In this connection the case of the Grand Canon of the Colorado may be cited. Here from 15,000 to 20,000 feet of sediments have been deposited upon the Archæan and later pre-Cambrian rocks, nevertheless they still lie almost horizontally. These, however, were not deposited *rapidly,* but occupied the whole of Cambrian and Post-Cambrian up to Miocene time in their formation. The Permo-Carboniferous basin at Maitland is an example of sediments which have been domed, the deposition of sediments being moderate in amount.

Summary of Geological History.

A great transgression of the sea appears to have taken place in the Cobar, Canbelego, and Girilambone areas in some pre-Silurian period, probably Cambrian, as suggested by the similarities of the metamorphic conglomerates, the quartzites, and the purple sediments, of the area under discussion, with the known Cambrian rocks of South Australia. This sea was shallow and was enabled to work over the loose rock masses littering the land over which it was gradually trespassing. Doubtless also, large streams brought down loads of coarse sediments to the sea. The shallow nature of the epicontinental sea is suggested by the strong conglomerates and the cross-bedded sandstones which occur abundantly in the sediments. Moreover, the transgressive action of the sea is suggested by the various localities at which the pebble beds occur, namely, Mount Dijou, Drysdale, Bee Mountain, The Rookery, Restdown, and other places. The greater portion of these pebbles are composed of tough quartzite, and they were derived probably from dense rock types of this nature belonging to a pre-Cambrian land surface. Wind-blown sediments are also indicated.

The widening of the seas does not appear to have been attended with great increase of depth, because the great proportion of the sediments consist of cross-bedded sandstones. The purplish and reddish colour of certain of the slates of Cobar and the yellow of the sediments of the Girilambone and Canbelego Series suggest arid conditions in part.

After an enormous thickness of conglomerates, sandstones, and shales had been deposited, a powerful compressive movement supervened with the formation of a great mountain range. So intense was the compressive action that the sediments were forced into a much narrower cross section,

with the formation of recumbent folds, as well as the puckering of the bedding planes, with a strong tendency to shearing and overthrusting. The more deeply-buried portions were altered to slates, phyllites, schists, and distorted conglomerates.

A period of erosion succeeded to the compressive activities and the resultant mountains were deeply dissected and much denuded.

Another period of sea transgression succeeded to the cycle of erosion and on the truncated edges of the sediments of the old complex a series of cherts, conglomerates, sandstones, and mudstones were deposited. The cherts were of radiolarian origin.

In the clearer portions of the epicontinental sea corals and other forms of life abounded, from the fragments of whose harder parts masses of limestone were formed. The individual beds of the series, namely, limestones, cherts, conglomerates, and sandstones, are characteristically thin.

A period of volcanism, with the production of great rhyolite flows appears to have occurred within this cycle of sedimentation.

An interesting point in connection with this Silurian history is that the rhyolite lavas in places are of alkaline nature, and are intimately associated with the radiolarian cherts.

Cessation of sedimentation was brought about by a strong compressive movement, but the metamorphism of the sediments during this movement of mountain-making was negligible.

The mountain range was next worn down to a plain by the agencies of erosion.

Sinking of the area ensued later with the deposition of conglomerates, quartzites, sandstones, and tuffs upon the edges of the truncated folds in Silurian and pre-Silurian sediments.

This period of sedimentation was closed, in turn, by a movement of folding on a scale much less important than that which had effected the older sediments at the close of both Silurian and Ordovician periods of deposition.

This orogenic movement is the latest of which we have any evidence in the area under consideration, and appears to have occurred at the close of the Devonian sedimentation.

No Carboniferous, Triassic, Jurassic, nor Cretaceous sediments have been found within the area, and the post-Devonian history appears to have been restricted to gentle uplifts or slight warpings, alternating with long periods of sub-aerial denudation, the effect of which was to produce low-lying plains of erosion at various successive periods.

Chapter IV.

THE ORE DEPOSITS.

Distribution of the Ores.

The metalliferous deposits of the Canbelego district are intimately associated with the Canbelego and Girilambone Series, and furthermore, the general orientation of the deposits conforms, in the main, to the prevailing strike of the associated sediments. The Series mentioned are composed of claystones, cross-bedded sandstones and quartzites, slates and phyllites with smaller developments of quartz, and mica-schist. As stated elsewhere, both appear to be limbs of a great fold, and the general strike varies from North and South to N.N.W. and S.S.E. In the mining community, so widespread is this knowledge of the association of the ore bodies with the older sediments of the district, that all gossan and quartz outcrops in such rock types are carefully prospected for copper and gold as soon as they are recognised.

Although the other series, such as the Weltie and Ballast, have been well prospected, nevertheless, nothing of commercial value has been traced, either in the radiolarian cherts, the claystones, shales, limestones, sandstones, or tuffs which comprise the greater portion of these series. This statement applies also to the sandstones, quartzites, and tuffaceous material of the Boppy Series.

The finding of the important Cobar lodes in 1869-70 gave a great impetus to prospecting in rocks of similar appearance in the district. Especially sharply was the search maintained for lodes possessing a trend either meridional or one a little west of north and east of south.

The distribution of the ores may be discussed in order as from east to west.

At Miandetta, about 40 miles east of Canbelego, an outcrop of serpentine was detected in the Girilambone schist, and prospecting operations by means of shafts and quarries were conducted for copper and gold. Nothing of value was found, however, as a result of the search.

At Honeybugle, also, the pyroxene rocks which have intruded the schists at that spot have been prospected for copper, but without favourable results.

Hermidale lies about 24 miles easterly of Canbelego, and the schists forming the country have been prospected by shafts, drives, crosscuts, and trenches. Copper values occurred in the upper levels of the Budgery, but the values appear to have been negligible in the many surrounding claims.

On the same strike as the metalliferous zone of the Budgery Mine, and 14 miles to the north, copper and iron pyritic deposits occur in the slates. These include the Budgerygar, North Budgerygar, and Bonnie Dundee veins. The Girilambone copper deposits, about 14 miles northerly of the Budgerygar mines, apparently occur along a strike similar to that of the Budgery and Budgerygar mines.

The long wide belt of the Ballast Series cuts off this mineral area to the west, and although a considerable amount of prospecting has been carried on in the area, no indications of payable ore deposits have been recorded therefrom.

The schists and slates outcrop again to the west of the Ballast Series, and numerous gossan outcrops have been prospected therein.

In this western group of the altered sediments the Restdown Copper Mine occurs at the junction of porphyry and slates, while the Restdown gold lodes occur in schists and slates some miles farther to the west.

At Canbelego the only gold lode of importance in the district occurs in the form of a large inverted saddle.

In addition to the main ore body numerous small lodes in the vicinity of the township have been prospected for copper and gold.

A few miles to the south of the township of Canbelego veins of copper have been worked, including the old Burra Burra, situated at the junction of schists, or slates, with quartz-felspar-porphyry, and the Canbelego Copper Mine, in slates and schists.

Still farther west a considerable amount of prospecting for copper, lead, and gold has been carried on at Rabbit Hill, but without payable results. It is uncertain to which sedimentary series the Rabbit Hill lodes belong, whether Weltie or Canbelego.

Throughout the whole of the Weltie Series, as well as the Mallee Tank Series (Cobar Copper and Gold Field, pp. 36-38), no ore deposits of commercial value have been found, although a considerable amount of prospecting has been carried on among these sediments at various periods. On the other hand, the Cobar Series, consisting of slates and metamorphosed sandstones, contain many ore deposits of great value; for example, the Great Cobar, the Cobar Gold, the Chesney, and the Occidental "Lodes."

A few miles to the west of the Cobar mines the older rocks give place to sediments of Devonian and of Silurian (?) age, and in these no ore deposits of value occur, with the possible exception of the C.S.A. and Tinto lodes, the age of whose enclosing sediments is unknown, but which may belong to either Silurian or pre-Silurian types.

Briefly, then, the sediments of the large district under discussion are arranged in six great parallel or sub-parallel bands, the older members being composed of slates, phyllites, schists, metamorphosed sandstones, and quartzites, these being separated in turn by wide belts of radiolarian cherts, shales, claystones, and sandstones, while the westernmost belt consists of Devonian shales (tuffaceous) sandstones and quartzites. The ore deposits of value occur within the older belts, while quartz reefs of negligible value occur within the cherts, shales, and sandstones of the intervening Ballast and Weltie Series. The westernmost series is practically devoid of quartz reefs.

Classification of the Ores.

In the Canbelego district the ore bodies fall naturally into two classes:—

(1) Gold deposits.
(2) Copper deposits.

Of these the gold deposits are the more important. Gold values, as might be expected, occur in the copper deposits, nevertheless they are not present in a marked degree. Similarly, traces of copper occur in the gold ores. The gold ores vary appreciably in character in the oxidised and sulphide zones.

The copper deposits are small individually, but they occur in greater numbers than those worked for the more precious metal. The minerals from these copper lodes may be classed as oxidised and sulphide ores.

Oxidised Ores.—In accordance with mining experience in Australia as a whole, the oxidised ores are generally rich both at and near water levels, but they rapidly decrease in value with increase of depth below this zone of permanent saturation. As with oxidised copper ores in other places, they appear to be alterations, partly, *in situ,* and partly as the result of the descent of oxidised copper solutions derived from sulphides once belonging to higher zones.

Sulphide Ores.—These fall naturally into two classes, namely, secondary and primary sulphides; in other words, they are due both to original precipitation and to the concentration of the ores of such original precipitation by wandering descending waters. Thus, in the Budgery Mine, water level occurs at a depth of about 400 feet. Below that level small patches of yellow copper sulphide were found associated with iron pyrites and siliceous material. At and near the zone of permanent saturation the ore was rich, consisting of chalcopyrite and chalcocite, while at still higher levels chalcocite, black oxides with green and blue copper carbonates formed rich bunches and masses. Upon these again rests the gossan cap containing stains of blue and green copper carbonates.

So far as prospecting operations have been conducted in this district the copper ores appear to belong to the chalcopyritic type in a gangue of quartz, altered slate, and iron pyrites, which appears at, and near, the surface as siliceous or dense ferruginous gossans stained with copper carbonate, which give place lower down to red oxides, green and blue carbonates, and black and yellow sulphides, while at moderate depths below water level the copper ores are of chalcopyrite only. At Cobar, however, 28 miles westerly of Canbelego, the chalcopyrite occurs in a gangue of pyrrhotite, magnetite, silicate of iron (Ekmannite?) quartz, and siliceous slate.

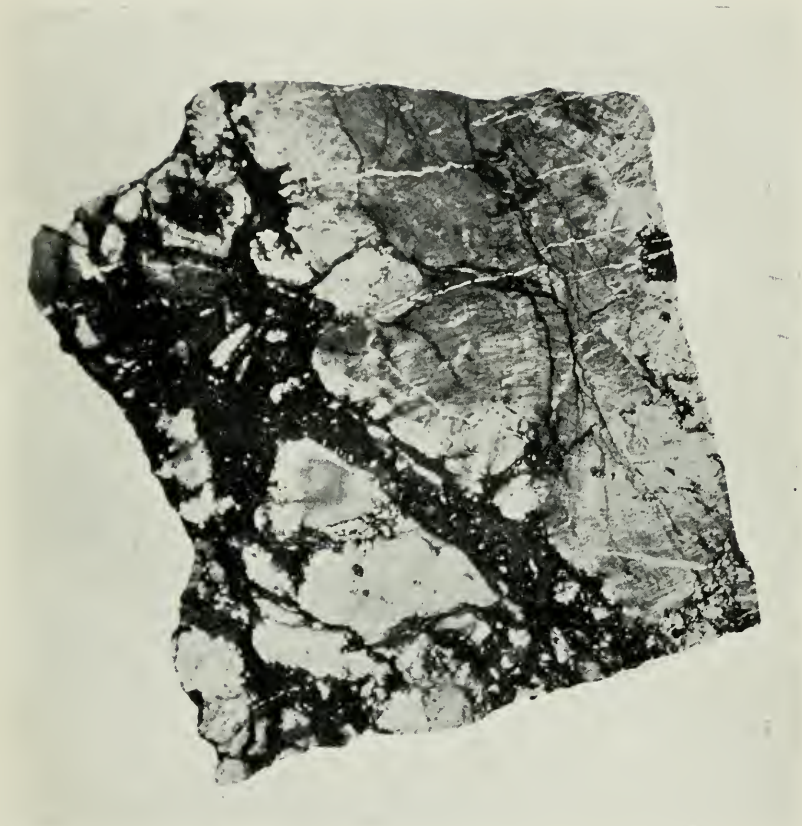
Mineral Paragenesis.

Under this heading is considered the association of the minerals of the ore deposits, and their gangues, with special reference to the method and order of their formation.

At the outset it may be noted that the pyrolusite, limonite, hæmatite, malachite, azurite, cuprite, native copper, carbonate of lead, copper glance (chalcocite), the richer bunches of yellow sulphide of copper (chalcopyrite), as well as much of the free gold, occurs in the upper portions of the lodes; while, on the other hand, at very slight depths below water-level, these give place to quartz and chert, with slate, containing crystals, threads, veinlets, patches and masses of iron pyrites, galena, zinc-blende, and chalcopyrite. The Mount Boppy lode, however, consists mainly of impure quartz and silicified slate, and its copper, iron, lead, zinc, and sulphur content is small.

The minerals of the first group are those of the zone of oxidation, while those of the second represent the original, or primary, association of ore and gangue minerals as they were deposited in the formation of the lodes.

The secondary minerals may be again divided into oxides and sulphides.



Association of chalcopyrite, zinc-blende, and galena in impure silica, Mount Boppy Lode.
The shaded portions represent the sulphide.
Tiny veinlets of quartz may be seen traversing the impure silica. x 2.

Ore from Mount Boppy Lode. Shaded portions represent iron pyrites breaking down into limonite. Light-coloured portions consist of impure quartz.

Primary Minerals.

Minerals of this class consist of iron pyrites, chalcopyrite (in part), galena (in part), zinc-blende (in part), gold (in part), glassy quartz and chert. The galena and zinc-blende appear to be mainly secondary, however, while the chalcopyrite appears to belong to both periods of deposition.

Iron pyrites occurs massive and as cubes in quartz and slate. In almost every instance of its occurrence, as at the Boppy Gold, the Bonnie Dundee, and the Budgerygar, Mines, the pyrites occur as cubes, either scattered or set closely together. Gossans from country thickly studded with such cubical pyrites have a texture frequently cavernous, to one almost spongy in nature, by reason of the removal of the cubes of pyrites by leaching. This method of occurrence for the pyrites clearly indicates its origin by replacement either of country or of the minerals in the lode.

Chalcopyrite is associated with quartz, iron pyrites, and altered slate in the Bonnie Dundee, the Budgerygar, the Budgery, the Canbelego Copper, and the Mount Boppy Copper, Mines. The typical occurrence is in veinlets, strings, and aggregations of tiny crystals and small patches of irregular shape. Thread-like occurrences of very small crystals also are to be found in quartz, and along joints, in the slate.

Galena and zinc-blende.—These apparently form but a minor part of the primary ore, and will be dealt with under the heading of Secondary Minerals.

Gold occurs bound up intimately with the sulphides below water level, but free gold also occurs, in places, below this level and it is difficult to decide whether such free gold is of primary or of secondary origin. One form in which it is found is as "paint" gold in tiny veinlets traversing the slate of the "centre" country in the Mount Boppy Gold Mine.

Silica occur both as glassy and opaque quartz, and as chert. The quartz occurs mainly in threads, veinlets, and veins (Plates VIII, XI, and Figs. 4, 4 [*b*]), while the intermediate areas are often occupied by cherts (Fig. 4). The silica in the Mount Boppy Gold Mine is characteristically of cherty nature, besides possessing a mottled appearance owing to the presence of the quartz, veinlets, and threads already mentioned. Such appearance is discussed in a later chapter, and is referred to the replacement of slate or silica which has entered the country along veins and veinlets. All stages, from sharply defined breccias of black slate in a quartz matrix (Plate X) to the impure forms of chert and quartz, may be found throughout the mine, and a great deal of the pay ore consists of this altered and replaced country.

Secondary Minerals—Sulphides. *Chalcocite*, or copper glance, always appears to be of secondary origin in the Canbelego district, inasmuch as it occurs in the lower portions of the gossan zones and extends thence to the water level and to slight depths only below that level. At depths somewhat below water level, chalcocite gives place to yellow copper ore (chalcopyrite) and to iron pyrites with quartz and altered slate. The chalcocite itself, however, is confined to the narrow zone at and near water level, where it may be seen to have formed veinlets and networks of strings through yellow copper ore, the latter itself being secondary in such cases.

Chalcopyrite.—Secondary copper pyrites apparently occurs both at, and near, water level, but its zone of formation is partly below that of the chalcocite horizon and partly overlapping it. Inasmuch as this mineral is the characteristic form in which the primary copper ore occurs, it is not so easy as in the case of the chalcocite to prove its connection with secondary deposition. The occurrence of rich patches of the yellow ore with the chalcocite, and the relatively impoverished nature of such class of ore, in lower zones, is one line of evidence relied upon as a proof of the secondary nature of the rich chalcopyrite masses near the water level. Another line of evidence is supplied by its peculiar method of occurrence, namely, as veins, strings, and masses, intimately associated with native copper and chalcocite in the upper portions and passing downwards gradually into the recognised primary ore.

Oxidised Ores.

Both *cuprite* and *native copper* occur with chalcocite and chalcopyrite, both at, and just above, water level. Native copper at times forms at the expense of the cuprite and chalcocite. In the Budgery Mine it occurred as broad, thin sheets deposited along narrow joints a little above water level.

Malachite and Azurite are typical of zones higher up in the lode than the chalcopyrite, chalcocite, and native copper contents. They appear to have been formed partly at the expense of the secondary sulphides and oxides, such as cuprite, and partly as redepositions of material of copper minerals leached out from higher levels.

Carbonate of lead has a very limited development owing to the scarcity of lead in the district. The mineral under consideration has been formed above water level at the expense of the galena. Neither native silver nor silver chloride was seen in the district by the writer.

Limonite is extremely common and occurs in various forms. The lode outcrops are generally in the nature of siliceous gossans fairly hard in nature. The superficial portions of the auriferous lodes of Canbelego, with the exception of that of the Mount Boppy lode, are of this nature. Around Canbelego itself, however, many strong outcrops of ironstone occur which appear to form the caps of strong lodes. The greater number of these, however, at slight depths, pass into insignificant veins almost free from iron. Ironstone caps of this class appear to result from the powerful action of the sun at Canbelego, in drawing solutions containing iron, magnesium, calcium, silicon, and allied minerals to the surface and there depositing them as limonite, calcareous tufa, magnesite, and silica, to form a dense cap. In a region of heavy rainfall minerals such as those under consideration would tend to escape, in solution, to the neighbouring water-courses, especially in areas of strong relief; but on the Plains, in the dry atmosphere of Canbelego and Cobar, such solutions, upon reaching the surface, are acted upon powerfully by the dry and hot climate, the water being evaporated while the iron and other residua form the ironstone (limonite) gossan.

The outcrops of the Mount Boppy Copper and Canbelego Copper lodes are strong siliceous gossans in which much massive limonite occurs.

The outcrops of the Budgerygar and North Budgerygar lodes are strong, and consist, in places, of a cavernous gossan representing the removal of iron pyrites from the lode by leaching processes and its redeposition as masses of limonite.

At the Budgery Mines the limonite outcrops were of a nature such as led to great expectations. A common feature in the mines in both this and the Cobar district is the occurrence of massive and hard limonite above water level. Throughout this dense material native copper sometimes occurs in strings of small crystals, or again copper glance may occur within it as veinlets, patches, or threads, or concretions. In some cases the appearance of the limonite near water level has led prospectors to consider it as solid copper glance.

Plate IX illustrates the replacement of iron pyrites by limonite in the Mount Boppy Gold Mine.

Hæmatite is found in places in the lower portion of the oxidised zone. In this district it is a secondary product and its usual associates are copper glance, carbonates and cuprite. It is possible that earthy forms of cuprite and hæmatite are at times confused.

Mention may be made, at this stage, of the general sequence of oxidised minerals in the copper lodes of the Canbelego district. The outcrops are of siliceous gossan with small quantities of manganese (pyrolusite). The slates above water level are brownish, yellow, or reddish, while below that level they are bluish in colour. The richer gold values occur above water-level, as a rule, while the payable copper values are met with at variable depths from the surface. Carbonates generally occur in the upper portions, while copper glance, cuprite, and native copper are found in positions still lower down, although the carbonates occur in some measure also in association with the copper glance and native copper. At and below water level copper glance occurs, but gives place gradually to the yellow sulphides, while these in turn decrease in value with increased depth until the zone of the primary ore proper is encountered.

Fig. 3 (b).—Slate breccia cemented by quartz. Footwall of eastern limit of Mt. Boppy Lode.

Geological Occurrence of the Lodes.

The ore bodies of the Canbelego district may be classed as lodes in the Australian acceptation of the term, namely, as masses of ore, either lenticular or irregular in shape.

These in great measure are due to replacement agencies. As examples of this Australian practice may be cited the Cobar, Mount Lyell, Mount Morgan, and Broken Hill, Lodes. A true lode, or vein, however, should possess a form which is broadly tabular, and, moreover, it should possess walls which are well defined.

The Canbelego deposits differ somewhat in character from those of the Cobar locality. In the latter area the rock types are represented mainly by slates and sandstones, while in the Canbelego area they consist mainly of slates, phyllites, schists, and sandstones. In all cases the lodes have a general trend of a few degrees west of north, although at times it is almost north-west and south-east, or again it may be a little east of north and south of west. In the Cobar area the deposition has taken place mainly along either sheeted zones,* or shatter zones, in the vicinity of faults, mainly overthrust in character, whereas in the Canbelego district the lodes may have definite dips, or they may represent replacements of folded country, as in the cases of the Bonnie Dundee and Budgerygar lodes.

The Mount Boppy copper lode occurs both at and near the junction of slates and felspar porphyry, but it is not a true contact lode, inasmuch as the ore body has been formed both in the porphyry as well as at the contact, and both the form and appearance of the lode are such as to suggest that the junction of porphyry and slate formed the plane of least resistance along which the Mount Boppy copper lode was deposited in the main. The Canbelego copper lode occurs in schists and slates, and has the appearance of a replacement body.

The Budgery deposit is strongly suggestive of a "pipe" or elongated lens, formed at the intersection of two planes of movement.

With regard to the dips of the lodes, it seems that both the Cobar and Canbelego examples have a general steep inclination to the east. Exceptions to this rule occur; for example, the westerly dip of the Queen Bee lode and the inverted saddle formation of the Mount Boppy gold lode.

On the other hand, deposition along fault zones in the Canbelego area appears to be conspicuous by its absence. Replacement along corrugations in the country, however, is strongly suggested by an examination of the Mount Boppy Gold Mines and its associates, so also by a study of the Budgerygar and associated deposits.

The Mount Boppy Gold Lode.—The country consists of slates and puckered sandstones. The slates and sandstones have been strongly folded with the formation of numerous secondary and tertiary folds, which appear as corrugations and puckerings imposed upon the main folds. In one of these corrugations the Boppy Gold Mine appears to have been deposited, giving the appearance of an inverted saddle lode, and the arrangement is such that the slates occupy the "centre" country, and the puckered and cross-bedded sandstones the outside country. The lode is more decided in appearance along what may be called its keel or trough. Along this there is more true quartz than along other portions of the lode, suggestive of a gaping-apart, originally, of the country, to a limited extent, and the filling of the resultant fissure by lode material, and the variable replacement therefrom of country, especially where it consists of shattered slate.

* A "sheeted" zone may be considered as consisting of a series of thin parallel masses of tabular form set closely together, and revealing little or no evidence of relative movement among themselves. Mineral solutions generally find ready access along the planes separating such parallel strips and thus give rise to lodes by replacement. Such zones, at times, assume a variety of overlapping arrangement instead of being persistent.

Slate breccia, with quartz cement. "Eastern Vein," Mount Boppy Gold Lode.

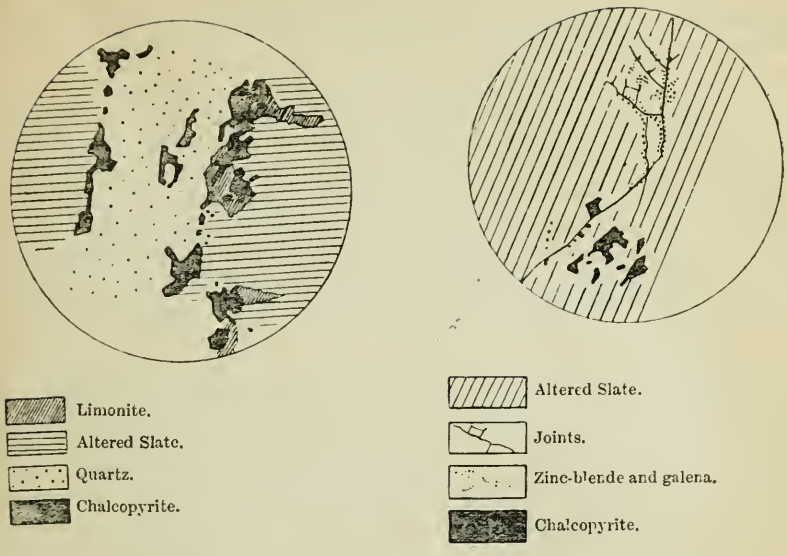


Fig. 3 (b).—Details of Mineral association in Mount Boppy Lode. x 20. Based upon microscopic sections.

In 1905 Mr. J. B. Jaquet, A.R.S.M., Chief Inspector of Mines, made a short report* on the geology of the Boppy lode, extracts from which are here enclosed. The conclusion Mr. Jaquet came to was that the lode is of inverted "saddle" nature.

"The geological formation consists of altered Silurian slates and schists, which are for the most part hidden from view by recent deposits of loam, the latter being from one to several feet thick.

. . . . . "The ore bodies vary in width from 6 to 50 feet. If the longitudinal section be referred to, the stopes in the northern end of the mine will be seen to terminate in their downward extension against the so-called 'slide.' The term 'slide' is, in my opinion, a misnomer, and misleading. We have here not a line of faulting, but a natural plane of parting between the ore and the country along the bottom of the saddle or synclinal fold. The so-called new-make of ore upon the west is nothing more than the western leg of an inverted saddle, of which the main lode is the eastern leg. The structure of the ore deposit will be more clearly understood after reference to the accompanying ideal plan, and longitudinal and transverse sections, and the actual sections taken across the reef. The curved base of the saddle-reef can be well seen at the 200, 300, and 400-feet levels respectively. It is met with in the 130-feet level at a point 360 feet north of the main shaft, and in the 400-feet level at a point 400 feet south of the main shaft. So it would appear that it pitches southward at a high angle. A glance at the longitudinal section will show that the angle varies between the different levels of the mine. It will probably be found that the whole ore body pitches south with the syncline, and a correct appreciation of this fact

*Annual Report, 1905, pp. 69–70, with plans and sections. Also, Records Geol. Survey N.S. Wales, Vol. VIII, 1905, pp. 179–182, with plans and sections.

should have a most important bearing upon the efforts which are being made to pick up the lode beyond the existing workings upon the Mount Boppy Mines and outside the company's leases.

"The Mount Boppy Company, acting upon the assumption that the lode had been faulted by a 'slide,' have driven through the ore and base of the saddle (slide) at the 130-feet level for a distance of 100 feet, and at this point have carried out a crosscut 200 feet in an easterly direction without meeting with the lode, and are continuing to drive the same. I certainly do not think any extension of the Mount Boppy lode will be encountered in this crosscut, or indeed anywhere north of a point distant about 200 feet north of the north shaft, since the bottom of the saddle outcrops about this point, and is denuded off beyond it. It is true, however, that parallel lines of reef, or even saddle-reefs, which pass below the Mount Boppy reef, may be found here.

"The Mount Boppy Company has sunk shafts upon G.Ls. 24, 22, and 44 respectively. These shafts are each 100 feet deep. At this depth a crosscut has been driven between the shafts upon G.Ls. 24 and 23 without meeting the lode, and crosscuts are now in progress between the shafts on G.Ls. 22 and 24, only about 200 feet remaining to be driven before the cross-cuts will hole through to one another. Should this happen without the reef being cut, which may very likely prove to be the case, a too pessimistic view of the matter should not be taken. The legs of those saddle-reefs which have been worked elsewhere do not extend downwards, or in the case of an inverted saddle upwards, for an indefinite distance, and it is quite likely that owing to the southern pitch of the syncline, the legs of the reef may at this point be considerably more than 100 feet below the surface, and the main body of the ore, which rides in the trough of the syncline, at a depth of several hundred feet. Indeed, the disappearance of the reef in the southern end of the upper levels may be due to the pinching out of the legs, and it will probably be found that as the greater depths are reached and the bottom of the syncline approached, the lode will extend further and further to the south. It would appear, if the lode be continuous, and the pitch of the main body of the ore does not materially alter, it must pass right under the cross-cuts.

"In this connection I should point out that the length of the legs of a saddle, or the distance they extend from the cap of the syncline or anticline, as the case may be, is liable to differ for each leg, and to vary considerably along the same lode. For instance, in the case of the Great Broken Hill silver-lead lode, using the cap of the saddle as a datum or starting point, the western leg seldom, if ever, extends more than 100 or 200 feet downwards, while the eastern leg (which has in at least one place been found to give out altogether at 300 feet) has been proved in other places to extend over 700 feet. At Mount Boppy reef there is some evidence to indicate that the western leg is not so persistent as the eastern, though the facts at present available are not sufficient to enable me to speak with exactitude upon this point. Again, a lode which may have the normal outline of a saddle throughout the greater portion of its length may, in some cases, owing either to the action of conflicting forces at the time of or subsequent to its formation, be distorted almost beyond recognition. This is noticeable in some places at Broken Hill, and the section through the main shaft, which appears elsewhere, shows how the Mount Boppy reef has been distorted at this point.

"The oxidised ore is composed essentially of quartz, with a small admixture of oxide of iron, and the unoxidised ore of quartz with iron and arsenical pyrites, galena, and zinc-blende. Gold is always present in an extremely fine state of division. The ore hitherto treated only contained insignificant quantities of copper, and this remark applies also to the unoxidised ore now being raised from the lower levels, as well as to the oxidised ore. It is on this account that the ore from Mount Boppy has been proved far more amenable to treatment than that from certain other mines in the Cobar District."

Mr. Jaquet also came to the conclusion that "other saddles may be found either inside or outside of—above or below—the reef now being worked, and also parallel lines of saddles." This clear statement by Mr. Jaquet has been amply confirmed by the examination forming the basis of the present report.

With a view to illustrating the peculiar form of the deposit and the genesis of the Mount Boppy lode, a number of transverse sections of the ore bodies have been reproduced, together with photographs of polished mineral and rock specimens, microphotographs of ore, and drawings from slides prepared for the microscope. From the text and accompanying figures it will be seen that the lode is a peculiar form of "inverted saddle-reef" due in great measure to the action of replacement along bedding planes.

Genesis of the Ores.

The problem of the origin of the ores of the Canbelego district may be discussed under several heads, namely:—

(1) Genesis of the ore channels.
(2) Genesis of the primary ores—
  (*a*) Method of entry into lodes.
  (*b*) Method of deposition.
(3) Genesis of the secondary ores.

(1) *Genesis of the Ore Channels.*

The field evidence shows that the rocks of the Canbelego district have been intensely folded and altered, and that, at a period (or at periods) much later than the metamorphism, the country has been disturbed with the formation of fissures and shatter zones which have afforded easy access to wandering solutions.

The Mount Boppy Gold, the Budgery and Budgerygar, lodes, may fall into a still earlier class in which the lodes were formed either along corrugations or pipes, not long after the folding. On the other hand, it is preferable to consider the principal lodes as belonging to one period of deposition. The geological features of the Canbelego district, namely, the widespread occurrence of slates, phyllites, and metamorphosed, as well as closely folded, sandstones, which have been truncated abruptly by the present plain surface, all point to the conclusion that the present surface was at one time deeply buried beneath a great rock load, and that the sediments now visible have been exposed only as the result of profound and long-continued denudation. These conclusions are confirmed in part by a study of the lodes themselves, which frequently assume a lenticular appearance both in a large way, as at Cobar, and in detail (Fig. 4), and also suggest replacement under a heavy load, as in the absence

of loading there would be a decided tendency for the rocks to snap at right angles to the trend of the small quartz-veins here figured instead of having the zones of strain filled by lenticular transverse quartz veins.

Breccias are forms common in lodes such as that of the Mount Boppy Gold Mine. Plate X, Fig. 3 (*b*), illustrate this feature. These forms, upon first examination, suggest crushing, and subsequent cementation, by quartz and other material. On the other hand, this apparent brecciation seems to be due, in the main, to the production of a network of cracks in the rocks and the filling of these veinlets subsequently with silica and other material.

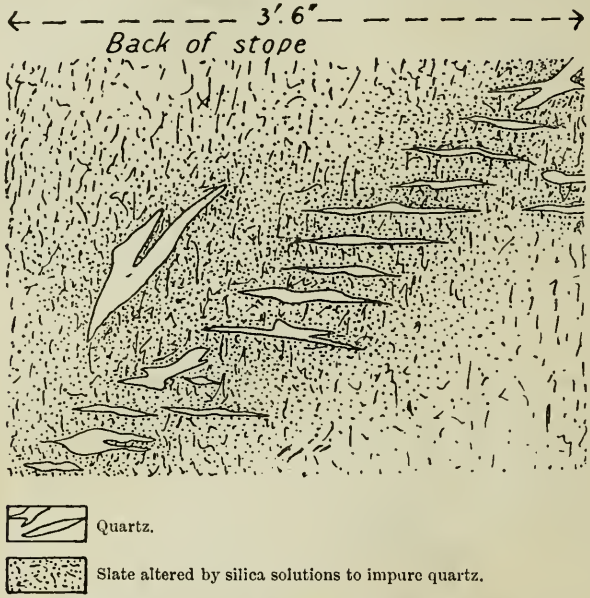
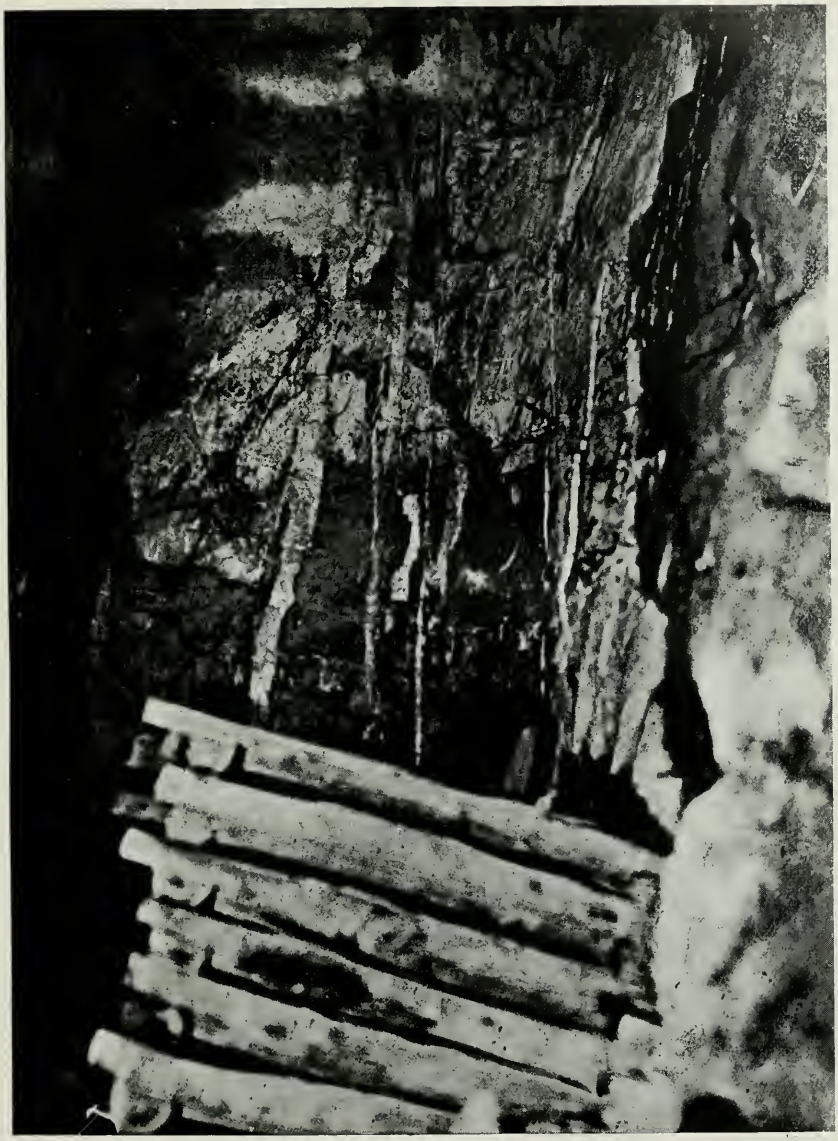


Fig. 4.—Detail of structure in Mt. Boppy Lode in stope above No. 3 Level.

(2) *Genesis of the Primary Ores.*

(*a*) *Method of Entry of Ores into Lodes.*—In many regions the direct dependence of ore deposits upon igneous rocks is plainly indicated. Striking examples are the relations of the tin deposits of New England (in New South Wales) to the acid granites, and their derivatives, such as the pegmatites, aplites, and quartz veins. Other instances are the relations of the Hillgrove gold, antimony, and scheelite deposits to the diorites, basic granites and lamprophyric dykes of the field.

In the case of the Canbelego ore deposits, however, this dependence of lode material upon igneous intrusions is not at all evident. It is true that a long line of quartz and felspar-porphyry, rhyolite, and tuffs occur a little to the east of Canbelego, but, in the first place, such occurrence appears to represent flows of lava; in the second place, lodes which lie near its junction with the slates also traverse the porphyry indifferently with the slates, and have affected it as much as they have the slates; in the third place, such extremely siliceous types of igneous rocks as the Canbelego porphyries are not associated, usually, with copper and gold deposits in New South Wales.



Mount Boppy Lode, Eastern Limb, No. 6 Level, showing association of quartz veins and silicified country.

Mount Boppy Stopes, No. 4 Level, illustrating association of quartz veinlets and slate replaced by silica.

In this State gold is commonly associated with the more basic granites, or with massifs of intermediate composition, and with dykes of basic types, while the copper is associated with more basic rock types.

This occurrence of lodes independently of igneous rocks is also characteristic of the Cobar district to the west.

If it be assumed, however, that these lodes are dependent for their origin upon the existence of igneous rocks which occur at a depth, even assuming that they have no surface representatives, then it seems a strange circumstance that a denudation so profound, and so widely-spread, as that which has resulted in the formation of the great plain of erosion at Cobar and Canbelego, should have failed to reveal the presence of such assumed masses of igneous rocks in some portion, at least, of this great area, for such igneous mass, if existent, could not have extended an important tongue towards the surface at any one place without being exposed at the surface by the great denudation of subsequent time.*

On the other hand, lodes such as those of the Budgerygar and the Mount Boppy Gold Mine must have been derived from *some* source, and that source appears to have been either the associated rocks or a group of rocks still more deeply seated.

It is here suggested that after a period of earth movements the rocks of the great district under consideration were strained in certain directions with the production of definite zones of weakness, and that solutions of deeply-seated origin were released from some region of decided pressure and heat, and escaped towards the surface along these zones of strain of weakness. The periods of ore entry may, or may not, be two in number. For example, copper occurs, in some measure, in all the lodes and both copper and gold deposits may be of the same age. On the other hand ore deposits of variable nature are to be found in all the rock systems of different ages in the district, but only those found in the oldest rock groups are of economic value.

In the case of the Mount Boppy lode the zone of weakness was of the nature of an inverted saddle (Plates XVIII, XIX) possessing a long and well-defined eastern leg and a poorly-defined western limb. Furthermore, the lode has been deposited at the junction of the slate and sandstone country. At the keel or trough of the saddle the lode has its most pronounced development, while to the south of the trough the lode is much contracted along each level. Plates XI, XII, XIII, illustrate the general association of the quartz, and the chert or impure silica and slate. Figs. 4 and 4 (*b*) also indicate the association of quartz and other lode material.

A careful study of these illustrations suggests that in one of the corrugations of the folds a small open space was formed at the junction of the slate and the cross-bedded sandstones; that the gaping action thus evidenced was emphasised at the trough of the fold, and that a shattering, or rather sheeting, of the slate took place in planes parallel to the small open space formed between the slates and sandstones. In proportion to the steepness of dip of this fold or corrugation so was there a tendency to press the slates and sandstones together, but in proportion as the pitch flattened so was there a tendency for the sandstones to draw away from the slates and for the slates to become sheeted. Having found access to a point in the trough of the corrugation, the ascending solutions could rise along the zone separat-

* In this connection it may be mentioned that several very small outcrops of gabbroid, or doleritic material, have been found in the Canbelego area. The occurrences are suggestive of small pipes or dykes, the greatest length found not exceeding 5 to 10 chains, and the greatest width 4 chains.

ing the main slate and sandstone masses which was partly in the nature of a shallow or narrow open space and partly in the nature of a sheeted mass. Plates IX, XII, XIII, and Figs. 3 (*b*), 4, illustrate the general association of the lode materials, while the general plan and the numerous transverse sections supplied by the General Manager of the Boppy Gold-mining Company illustrate the general appearance of the corrugated rock masses both in section and in plan.

Other details are supplied in the chapter dealing with the Mount Boppy lode itself.

In the case of the Budgerygar and Bonnie Dundee lodes, the ores have entered and traversed a corrugated and puckered zone of slates or schists. Only certain members of the sediments have been affected (Pl. XXXVIII), and it would appear that the wide zone of alteration containing the lodes represents a belt more porous and weak than the surrounding sediments, and that the ascending solutions entered and gradually worked their way upwards along this porous mass in subparallel layers.

The case of the Budgery lode is more complicated. Its shape (Plates XXXV and XXXVI) is suggestive of a pipe, and the associated country is composed of sandstones, slates, phyllites, and schists. It is probable that the ore solutions in this case have worked their way upwards along the intersection of a set of joints formed at the angle of a double fault. This, however, is only an inference, the evidence* not being sufficient to prove such a statement. This idea, however, might be accepted as a working hypothesis which would admit of being tested later by an examination of future workings.

Having considered briefly the probable origin of the primary ores as heated solutions which ascended either from some deeply-seated igneous mass or from some zone of heat and pressure at a depth, and which worked their way upwards subsequently along either sheeted zones, troughs of saddles, or joint intersections, it will be advisable to consider the method of deposition of the primary ores.

(*b*) *Method of Deposition of Primary Ores.*—The most important ore deposit needing consideration in this connection is the Mount Boppy lode. The country consists of well-cleaved slates and puckered sandstones of cross-bedded nature. The minerals of the lode are gold, silver, galena, zinc-blende, chalcopyrite, calcite, quartz, and chert. The elements involved are gold, silver, lead, zinc, copper, iron, calcium, silicon, sulphur, and oxygen. All the minerals considered are those which might be expected to occur indifferently under conditions of either little or great heat, and of slight or great pressure.

The impression gained upon a casual glance at the ore body, especially that portion occupying the trough of the saddle, is that the ore consists of quartz which has been deposited in an open space. A detailed examination, however, leads to the idea that the filling of open spaces by quartz in

* It may be stated, however, that the footwall is fairly well defined, while the hanging wall is very ill defined, owing to the gradual decrease in alteration (by the introduction of pyrites and the minerals) from the strong footwall towards the crushed country of the hanging wall. This furnishes additional ground for considering the lode to be due in part to faulting action:

Mount Boppy Lode, illustrating the general appearance of the ore in No. 3 Level stopes. The lighter-coloured portions of the ore body represent quartz veins in cherty slate.

Mount Boppy Stopes, showing association of quartz veinlets and silicified slate.

this lode was only a portion of the activities concerned in the Boppy lode formation. Plate XII shows the quartz veins, with included slate fragments, and the associated mass of chert or allied material which appears to have been formed at the expense of the slate country.

Plate XI and Figs. 4 and 3 (*b*) also illustrate this association of quartz and chert or impure silica in a decided manner, and suggest that the quartz bodies represent the filling of a fissure, or a network of fissures, and that the impure and more "waxy" silica has resulted from the replacement of the slate in the vicinity of the fissure or fissures. An examination in detail of the lode tends to confirm this idea. Thus, in Plate X, an apparent breccia is figured, in which the cementing material is, in part, ordinary quartz, and, in part, waxy silica of impure nature. All transitions between this apparent slate breccia with a silica cement and a mass of waxy quartz, traversed by quartz veinlets, are to be found. The outcrop, almost without exception, at first sight, appears to consist of an impure variety of quartz, but, in the majority of instances, this material may be shown to consist of fragments of colloid quartz separated by tiny veins of ordinary quartz. This colloidal quartz, with silicified slate, constitutes by far the greater portion of the deposit, and the various photographs and figures here reproduced appear to prove, beyond any reasonable doubt, that the lode is due in great measure to replacement agencies.

Iron pyrites does not form a highly important portion of the ore bodies, but it is evidently a result of replacement. In the Boppy gold lode it may be observed as aggregates of small cubes arranged along bedding planes, and along very thin porous beds. In the slates of the "centre country" tiny threads of mineral of a colour brighter than that of the ordinary slate may be seen following the bedding planes. Under the microscope these are observed to consist of a silicified slate containing very small cubes of iron pyrites, the cubes occurring either as lenticular aggregates set in a siliceous cement or a series of discontinuous individual crystals. Such an association of minerals appears to mark an early stage in the replacement of the country.

A much more advanced stage in the replacement of slates and schists by iron pyrites is revealed by a study of the Budgerygar and Bonnie Dundee lodes. Plates XXXVIII and XXXIX illustrate the replacement of country by iron pyrites. The pyrites have been formed along the puckered bedding planes, but not to the complete exclusion of other minerals. In hand specimens one might mistake the ore for solid iron pyrites, with admixtures of zinc-blende, galena, and chalcopyrite. Under a lens, however, the whole mass may be seen to consist, in the main, of altered slate or schist, in which a great amount of separate pyrites crystals have been developed along parallel or subparallel curved surfaces. Upon weathering, this material gives place to a peculiar cavernous gossan, owing to the removal of the pyrites by leaching.

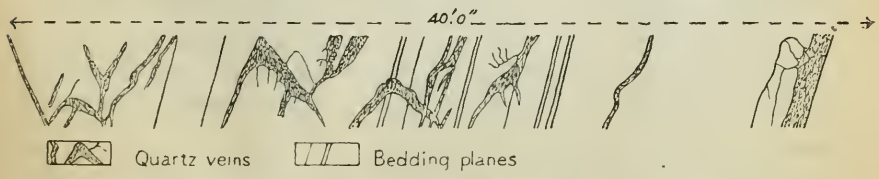


Fig. 4 (a).—Sketch section across stringers from Western formation of Mt. Boppy Lode. No. 3 Level.

Replacement by chalcopyrite, galena, and zinc-blende will be considered under Secondary Ores.

(3.) *Genesis of the Secondary Ores.*

These include gold, chalcopyrite, chalcocite, galena, zinc-blende, hæmatite, and limonite.

Gold.—In the primary ore this appears to be bound up mainly with the sulphides. In studying the bands of iron pyrites of the Mount Boppy lode under the microscope, or under a strong lens, the pyrites of the upper levels may be observed to be breaking up into patches and strings of limonite. (Plate IX.)

In Plate IX the chalcopyrite also is seen to be breaking up into fresh minerals with the production of limonite. The gold which was originally bound up in the primary sulphides has been set free by the conversion of the latter into limonite and other minerals, and appears to have been deposited in a fine state along tiny joints, or in small cavities.

Chalcopyrite.—Fig. 3 (*b*) illustrates the usual development of this mineral in crystals, crystalline aggregates, or as threads of crystals along joints or porous material. The chalcopyrite may be seen developed also as aggregates, or as meshes, within networks of iron pyrites crystals.

In many cases it is not easy to decide whether the galena, the zinc-blende, or the chalcopyrite has been developed first among the secondary minerals. The study of numerous specimens suggests that sometimes one and sometimes another was formed before the others.

Chalcocite.—Copper glance is found in the Budgery, Budgerygar North, Mount Boppy copper, and Canbelego copper lodes, but it has not been recorded from the Mount Boppy gold lode. The method of occurrence is much the same as in the Cobar mines. Wherever found in these areas, it is secondary in nature, occurring only as an enriched sulphide in a zone which partly overlaps, but, in the main overlies, that of the secondary chalcopyrite. The chalcocite is intimately associated with the zone just above water level. In the districts under consideration it is never found at other than moderate heights above, and moderate depths below, the zone of permanent saturation, and it appears to have replaced the chalcopyrite in great measure. Furthermore, in the Mount Boppy Copper Mine, specimens of chalcocite may be seen studded with grains and particles of chalcopyrite representing kernels of yellow sulphide not at present replaced by the richer sulphide. In other specimens the chalcopyrite appears to have formed as crystals within the chalcocite. In the Budgery Mine the chalcocite has replaced leaner sulphides, which in turn had previously been deposited within corrugations or puckerings in the schistose rocks of the locality.

Galena and Zinc-blende.—These minerals are not of common occurrence in the Canbelego district, and their association at the Mount Boppy Gold Mine alone is here considered, because of their interest in connection with the gold contents of the lode.

The galena of the lower levels of the mine may be primary in nature, but it is highly probable that much of the zinc-blende found at the 600 and 700 feet levels is secondary in nature. The primary galena was probably altered, in great measure, to sulphate of lead by oxidising agencies, and in this condition it was maintained in solution only with difficulty, and this became

precipitated as secondary galena at slightly lower depths. On the other hand, the zinc-blende of primary origin, whenever acted upon by the more superficial solutions, has become converted, in the main, to sulphate of zinc, a very soluble product, and one which would easily descend to greater depths below water level than the insoluble lead sulphate without being precipitated as a sulphide.

The more payable ore from the mine is said to be that which contains a high percentage of zinc-blende, and, in the formation of this secondary zinc-blende, it would appear that the gold has been enveloped by, or intimately associated in some manner with, the sulphides, especially the zinc-blende.

This apparently explains the occurrence at moderate depths below water level of a considerable percentage of zinc-blende in the ore, but associated with only minor quantities of galena.

Both galena and zinc-blende are finely-textured, and they have been deposited as replacement products in the form of threads, of aggregates of tiny crystals, of bunches and of veinlets in the slates, quartz, and cherts.

The minerals appear to have replaced the surrounding material in the neighbourhood of joints. In one large block at the mine about 50 or 60 lb. in weight, which contained about 70 per cent. by weight of zinc-blende, and in which the remainder of the material consisted of chert, or impure quartz, with a minor development of crushed slate, the zinc-blende was seen, in the first place, to have worked along very narrow bands either subparallel or parallel, and to have gradually replaced the rock between these bands. Beyond these zones of circulation the zinc-blende had gradually eaten its way along tiny quartz veins into the chert, replacing these with the production of zinc-blende aggregates in the shape of blunt projections.

Kernels of chert occur within the secondary blende. Secondary chalcopyrite also may be seen forming discontinuous veinlets which, as a rule, are arranged alongside the blende. Fig. 3 (*b*) illustrates the method of replacement noted in the galena, namely, by the replacement of quartz and other material along miscroscopical joints, and the formation thence of aggregates of loosely-connected crystals in the surrounding material.

The figure similarly illustrates the formation of crystalline copper pyrites along definite planes of weakness.

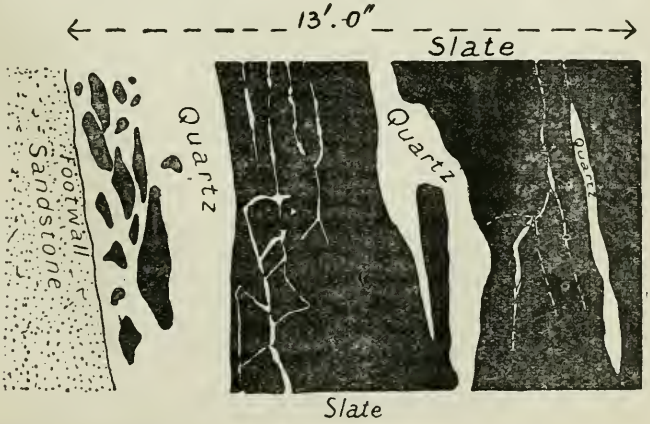


Fig. 4 (b).—Quartz Veins in Slate along Eastern Vein on No. 6 Level. Mt. Boppy Lode.

Oxides.

Cerussite.—The mineral is of rare occurrence, owing to the subordinate development of lead ores in the district, and needs no consideration in this report. It has been developed from the galena within the gossan zone.

Oxides of the copper ores include red oxides, as well as blue and green carbonates. These have been described already under the heading *Paragenesis.*

Hæmatite is rare. It is an anhydrous form of iron oxide, and has been developed from the chalcopyrite and the iron pyrites. It occurs near the water level.

Limonite.—A hydrous form of iron oxide, which has a great development at Canbelego. It appears to have been derived from the iron contained in the chalcopyrite and the iron pyrites, and it has been redeposited in a variety of ways, as already stated under the head of Paragenesis. Plate IX illustrates the passage of iron pyrites and chalcopyrite into limonite, and the deposition of the limonite products within the quartz or chert (in part).

Topographical and Climatic Influence.—As at Cobar, so the country both at and in the neighbourhood of Canbelego is a plain of erosion, with a sub-arid climate. Water level occurs at a depth of about 225 feet at Mount Boppy in No. 3 stope, in the trough of the saddle (the depth, however, is variable in the lode), about 200 feet in the Mount Boppy copper lode, about 320 feet in the Bonnie Dundee Mine, about 350 feet in the Budgerygar Mine, about 400 feet (on the underlay) in the Budgery Mine, and about 155 feet in the Canbelego Copper Mine.

An examination of the country suggests that the country has remained as a low-lying area for a very long period of time, and this, in turn, suggests a long period of stable equilibrium for the general water level in each mine. This, of course, assumes that the climate of that period remained somewhat similar to that of the present. A study of the secondary ores in the various mines leads one to the belief that they fall within one period of deposition by reason of their simple arrangement.

Under such conditions of the topography, as here outlined, one would expect to find huge masses of rich secondary ores in lodes of considerable size, provided that the primary ore was of considerable size, and of even moderate value. In a district such as Canbelego, where the topography is so favourable to the formation of secondary enrichments, the absence of large and rich deposits near water level, in the case of the copper mines, indicates the poverty of the primary ores. In striking contrast to this condition of things in the Canbelego district, one has only to consider the Great Cobar and Broken Hill Mines, where lodes possessing primary ore of rather lean values, but of immense size, were capped by very large, and at the same time by wonderfully rich, secondary ores.

The effect of secondary enrichment in connection with the gold contents of the Mount Boppy Gold Mine is not quite understood by the writer. A careful study of the other minerals of the lode, and their association with the gold, however, suggests that much of the gold hitherto won, especially along the trough of the saddle, is of secondary origin. In the present stage of the inquiry it is almost impossible to ascertain the average tenor in value of the primary ore.

The foregoing remarks concerning the production of secondary ore deposit, under favourable topographical conditions, such as exist in the Cobar

and Canbelego districts, must not be taken as applying to the more eastern districts of the State, for here the topography is youthful and rugged. At Lobb's Hole a copper lode outcropped as solid yellow pyrites in the bed of the river. In other localities also within the State copper pyrites has been known to outcrop at the surface in areas of rugged topography.

Both in these and the general type of ore deposit within the dissected plateau region the ore deposits are small, and the water-level is practically coincident with the land surface. In the opinion of the writer there is little or no opportunity in such areas in New South Wales for the production of large deposits of oxides and secondary sulphides.

Summary of genesis.—A great mountain range was produced at least twice in the Canbelego district during the earlier portion of Palæozoic time, one at the close of the Silurian, the other apparently during some earlier period. In the older series of rocks, which consist of slates, phyllites, schists, and highly-folded (as well as cross-bedded) sandstones, a series of sharp corrugations and puckerings were produced on the shoulders of the major or minor folds, and, moreover, a series of planes or zones of weakness were also produced. Either by reason of this, or of still later, movement, the underlying rock masses were relieved in some measure of the great pressure to which they had been subjected, and as a result of such relief of pressure a tendency was developed among these rocks to expel heated metallic excretions towards the surface. In several cases, as those of the Budgery, Budgerygar, and Bonnie Dundee lodes, the corrugated bedding planes of certain sediments formed the planes or paths of easiest ascent; in the case of the Mount Boppy lode it was the trough of a steeply-pitching syncline which formed the easiest path for the ascending solutions; in other cases, again, the junction of two rock types formed the path of least resistance for the passage of the solutions. Of these the Mount Boppy copper lode formed near the junction of slates and porphyry is an example.

The solutions contained much silica, with which were included subordinate amounts of iron, copper, lead, zinc, gold, and silver.

The ores in a minor degree have been deposited in open spaces, but in the main they are in the nature of replacement products of the slate and sandstone country. In the case of the Mount Boppy gold lode an actual open space, or at least a series of interlacing veinlets, was formed in the slates at their junction with the sandstones. Nevertheless, a great portion of the lode appears to consist of replaced slate. In the cases of the Budgerygar, the Bonnie Dundee, and allied deposits, no open fissures appear to have been produced.

There appears to have been a later movement of the Mount Boppy gold lode on the footwall of the eastern limb.

The old mountain range, within which the lodes were formed, was worn away to a plain at an excessively slow rate. Especially slowly were the final stages in the formation of the plain carried out, because of the greatly diminished power of stream erosion during such a period. The climate is sub-arid, and has evidently been so for a considerable time. Water-level varies in depth from 150 to 400 feet below the land surface, and the descending waters, in the presence of the usual reagents, have formed sulphates, more or less soluble, from the sulphides of iron, copper, lead, and zinc in the lodes, and these have been redeposited, in part, as oxides and carbonates, or as native metals, above water-level, and, in part, as sulphides at, and near, that same level.

Relative Ages of Canbelego and other New South Wales Lodes.

In Part I of this report, the Cobar lodes were referred, temporarily, to the close of the Devonian period. This conclusion was reached from a consideration of the probable ages of the sediments. In the present report, however, additional evidence of the age of the sediments is presented, and it appears preferable to consider the Cobar, Canbelego, and the Girilambone Series as being pre-Silurian, rather than Silurian, in age, reserving the term Silurian for the less altered Ballast, Weltie, and related series.

From a consideration of the distribution of the ore deposits, it would appear that the older rock types contain the deposits of importance, while the younger types, although containing lodes, nevertheless contain none of importance. As an example, the Devonian sediments of Canbelego are known to contain definite gold-quartz reefs, nevertheless in no single instance have they been found to be payable. Similar reasoning may be extended to sediments known to be definitely Silurian in age.

The inference from observations such as those recorded in the present report is that:—

(1) The lodes in all cases may have been deposited at the close of the Devonian period, and the mineral composition, together with the structure of the most altered rock types, may have permitted the formation of important ore deposits therein, but the nature of the Silurian and Devonian sediments themselves may have been unfavourable to the development therein of ore deposits, thus restricting the occurrence of the payable deposits to the older rock formations.

(2) The lodes may have been deposited at the close of the Ordovician (?), the Silurian and the Devonian periods alike. On this assumption the later deposits are unimportant commercially.

Of these it is probable that the latter inference is the more correct, or at least that there have been two periods of ore formation, one prior to, and one later than, the Devonian sedimentation. A similar association occurs in the Forbes-Parkes area where Devonian, Silurian, and pre-Silurian sediments occur in juxtaposition. The Devonian rocks in that district are gently folded as a whole, but have been pinched locally into sharp folds within the older sedimentary basement. The Silurian sediments consist of unaltered limestones, claystones, and cherts which have been gently folded, and these abut against a mass of well-cleaved slates, phyllites, sandstones, and quartzites, which have been closely folded, and whose age appears to be Ordovician. Only in the oldest of these groups are there any ores of commercial importance, although signs of small quartz veins have been found in the associated Silurian sediments.

This reasoning may be extended to areas lying east and south of those just described. It is not many years ago that the sediments in which the ore deposits of the Monaro, Orange, Bathurst, Shoalhaven, and neighbouring areas were considered to be Silurian in age, but the geological evidence accumulated during the past seventeen or eighteen years has gradually been such as to throw grave doubts upon the occurrence of payable gold veins within these areas, in sediments younger than the Ordovician. Some of the tin, copper, and lead zinc ores, however, doubtless belong to younger periods of ore deposition within the same areas.

The Broken Hill deposits are recorded as probably of pre-Cambrian age, by Dr. D. Mawson.* These occur in the extreme western portion of the State.

It is then evident that, in the western portions of the State, the important lodes are of very great age, possibly pre-Cambrian, or closing Ordovician (inasmuch as the Cambrian sedimentation itself may not have been closed by a strong compressive movement). At Cobar, Canbelego, Forbes, Parkes, and other districts in the central portion of the State the lodes of commercial value occur in the pre-Silurian (?) sediments, while smaller lodes only carrying gold occur in the Silurian† and Devonian rocks.

In the districts east of those just mentioned the Ordovician sediments appear to contain the gold reefs of commercial value, but certain copper, lead-zinc, and tin deposits occur also in Silurian, and even Devonian sediments, in that region. (Example: The Lobb's Hole Copper Mine in Devonian rocks.)

No ore deposits appear to have been formed at later dates than these for the areas in New South Wales outside New England.

In Western New England itself, as mentioned by W. N. Benson, gold, copper, and other deposits were formed possibly about the close of the Carboniferous period, while in northern New England the tin, gold, silver, and copper veins appear to be of closing Palæozoic age.‡

The obvious conclusion from this evidence is that ore deposition slackened and finally ceased with progress of time within New South Wales in directions both as from west to east, and as from south to north. This conclusion is practically applicable to Australasia§ as a whole.

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*Geology of the Broken Hill Area, Proc. Roy. Soc. S. Aus., 1913. †Mr. Leo. Jones, Field Assistant, informs me that the small Welcome Reefs near Nerriga, which are worked for gold may occur in Silurian sediments. The Cargo Gold Reefs, examined by Mr. M. Morrison and the writer, occur in altered quartz-felspar-porphyries, andesites, and breccias of unknown age, and associated with Silurian sediments. ‡E. C. Andrews, Drake Gold and Copper Field, Min. Res. No. 12, Department Mines, N.S. Wales, 1908. §The famous Walhalla Gold Mine, however, in Victoria, occurs in Silurian sediments.

Chapter V.

DESCRIPTIONS OF MINES.

Mines worked by the Mount Boppy Gold-mining Company.

Mines considered.—The Mount Boppy Gold, the South Mount Boppy Gold, the North Mount Boppy Gold, the Canbelego King, the Birthday, and the East Mount Boppy Mines.

(*a*) The Mount Boppy Gold Mine.

Situation.—The lode worked by the Boppy Gold-mining Company lies alongside the township area of Canbelego, and all the land not actually occupied for general town purposes is leased by the Boppy Gold-mining Company.

Leases.—These include G.L. 1 (10 acres), G.L. 8 (10 acres), G.L. 9 (13 acres), G.L. 14 (8 acres), G.L. 17 (10 acres), G.L. 18 (10 acres), G.L. 19 (8 acres), G.L. 20 (8 acres), G.L. 21 (10 acres), G.L. 22 (5 acres), G.L. 24 (4 acres 2 roods 15 perches), G.L. 31 (8 acres), G.L. 36 (10 acres); G.L. 37 (10 acres), G.L. 38 (3 acres 2 roods 36 perches), G.L. 43 (10 acres), G.L. 44 (10 acres), G.L. 52 (6 acres 1 rood 8 perches), G.L. 53 (7 acres 3 roods 1 perch), G.L. 59 (8 acres), G.L. 74 (1 acre), G.L. 77 (1 acre 2 roods 10 perches), G.L. 88 (20 acres), G.Ls. 78, 82, 83, 84, 87, 92, 93, and 94, parish Cohn, county Robinson, and G.Ls. 10, 11, 17, 25, 89, and 91, parish Florida, county Canbelego; M.P. 2 (3 acres 2 roods 30 perches), and 75 freehold (1 acre), parish Cohn, county Robinson.

History.—The sequence of events which culminated in the discovery of Mount Boppy Gold Mine by Reid and O'Grady has already been supplied in the chapter on the general history of the field, and in the present chapter only a few additional items of historical interest are supplied.

At the close of 1900, leases to the extent of 168 acres had been secured, while those leases which had previously been held by the Anglo-Australian Exploration Company had now passed under the control of the Mount Boppy Gold-mining Company, Limited. The accompanying description of the mine at this stage is from a report by Mr. Inspector J. B. Godfrey.*

"Mount Boppy.—The work of developing and opening up this mine has been steadily carried on with the result that the reef is opened up at the 150-foot level for over 900 feet in length; winzes have been sunk in several places to the 200-foot level, while the main shaft has been cut down and timbered and sunk to the 200-foot level, and drives started from it. As soon as the plant is completed all that is necessary is to put on the men, and stoping can be commenced at once and continued uninterruptedly. The stamp mill and winding machinery came from the Galleymont Mine at Galley Swamp, and have been re-erected here. The battery consists of forty head of stampers, with self-feeders and all modern appliances. The winding engine is a very serviceable one, and the cages are fitted with efficient safety catches and overwinding gear, and their position in the

* Annual Report, 1900, p. 130.

Henry Shaft, Mount Boppy Gold Mine.

shaft is accurately shown by indicators worked by chain and sprocket. The poppet-heads are the best in the district; they are about 60 feet high, of dressed Oregon pine, set on concrete foundations, treated with cyanide solution to prevent the inroads of white ants, and instead of having heavy wooden braces as usual, they are braced with steel tension or tie-rods. . . . So far as can be judged at present the mine should have a successful future. A cyanide plant is in course of erection, and a reservoir has been excavated with a cubic content of 70,000 yards, or nearly 12,000,000 gallons capacity, and once rain falls and fills the tank there should be no future anxiety regarding water supply."

Reporting on the mine in 1900,* Mr. Inspector Schloesser stated that the ore which had been won up till that time was "a working sample of the mine as developed down to the 250-foot level." The work done, he stated, justified the purpose of the company to erect an additional forty-head of stamps.

By the close of 1902 the mine had been developed to a depth of 310 feet, and the lode had been proved to be large.

Already, in 1904, it had been recognised that the Mount Boppy Mine was the premier gold mine of the State. During the year the battery was increased from forty to sixty head of stamps.

The pulp from the battery was passed over plates, thence to Wilfley tables. Thirty per cent. of the gold recovery was reported to be due to processes of direct amalgamation, 35 per cent. from cyanidation of sand, 25 per cent. from cyanidation of slimes, and 10 per cent. from concentrates.

In the same year Mr. J. B. Jaquet, A.R.S.M., Chief Inspector of Mines, made a report on this lode—a copy of which is reproduced elsewhere under the head of "Geology of the Ore Deposits." Mr. Jaquet described the occurrence as an "inverted saddle lode."†

A new company with a nominal capital of £150,000, and a working capital of £60,000, of which £50,000 had been subscribed, was formed in London "to work the southern leases of the Boppy Mine, together with what is known as Bakewell's leases, and the leases of the Boppy South Gold-mining Company."‡

Work continued uninterruptedly on the Mount Boppy lode until 1911, the mine holding premier position for the whole period among the gold mines of the State. The dividends paid up till the close of that year totalled £412,533, or a return of 351 per cent. 329 men were employed during this period.

The Henry shaft had been sunk to a depth of 727 feet, a plat had been cut, a cistern excavated, and a pump fixed. An extension of the 600-foot level revealed an excellent body of ore about 450 feet north of the Henry shaft. Payable ore had been developed to the extent of 357 feet in length with an average width of 22 feet, and an average assay of about 15 dwt. of gold per ton. With increasing depth zinc-blende was observed to be present in increasingly proportionate amounts, whereas in the upper sulphide levels blende and galena were present approximately in equal amounts.

* Annual Report, 1901, p. 89. † Annual Report, 1905, pp. 69–70, with two plates.
‡ Annual Report, 1906, p. 11.

The following note which has been extracted from Mr. Inspector Oldfield's report for 1912 shows the position held by the Mount Boppy Mine at the close of that year:—

"*Mount Boppy Gold Mine.*—This still remains the premier producing gold mine of the district. During the year 53,990 tons were raised and treated, a decrease of 20,142 tons on the previous year, the value of the year's output being £73,506, a decrease of £37,904. The ore produced came mostly from Nos. 3, 4, and lower levels. A fair amount of ore has been exposed by recent developments at the lower levels, and the future prospects are highly encouraging.

"During the year the mine was closed down owing to shortage of water for some time, and the substantial decrease of the production has been due to this cause, and also to the erection of the new slimes plant. This new plant has been erected at a cost of £17,000, whereby only one product is to be made, and it is expected to save 85 per cent. on all ore now being treated.

"A record yield is expected for the coming year."*

Extracts from the report of the General Manager to the Directors of the Mount Boppy Gold-mining Company are also here reproduced:—

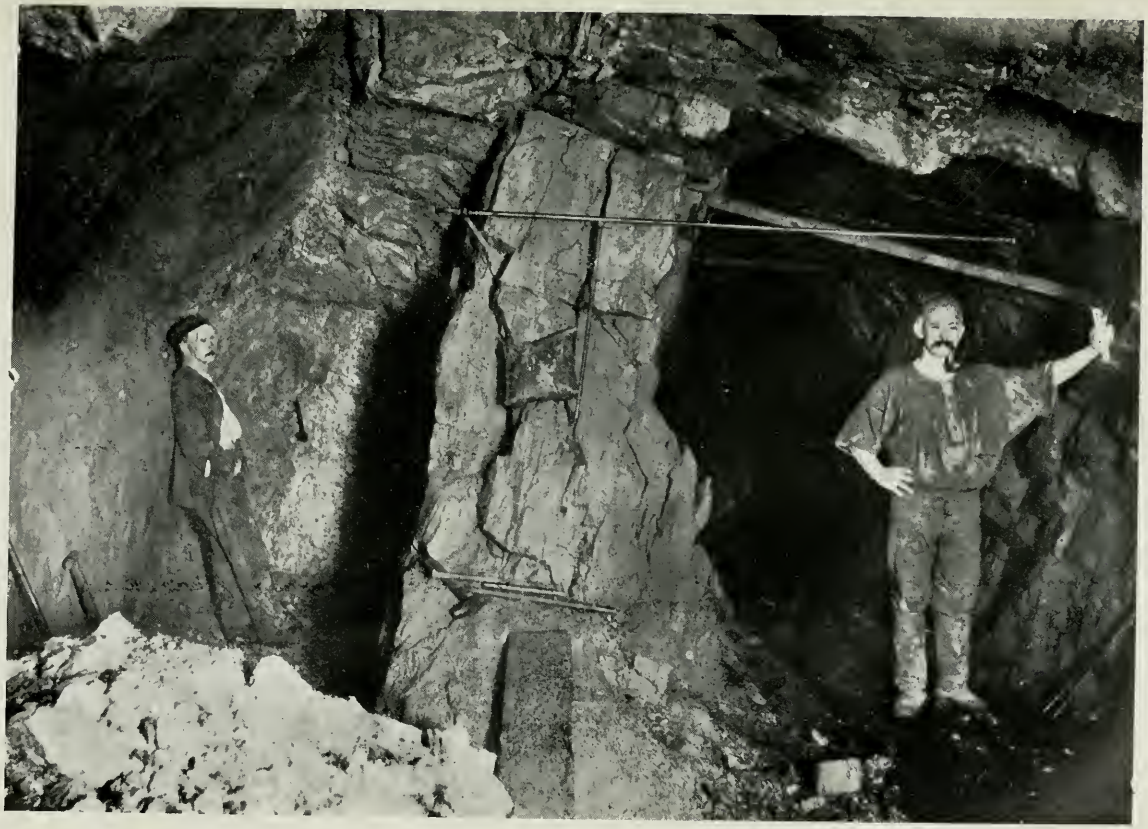
"The chief interest during the year has been centred in the two bottom levels north of Henry shaft. At the end of the preceding year the 600-foot level was revealing an ore body of great width. The ore was resting on the eastern wall, and the north end of the trough stoping continued round the bend of the trough in the direction of the western wall. This work proved there was a division in the lode and that the real western wall had taken an unusual turn to the south-west. The ore continued to open up satisfactorily in the same direction until the width increased to 60 feet. The last few feet in length of the ore on the western wall consisted of bands of slate and quartz carrying numerous veins of mineral, all running in a south-westerly direction, with a tendency to join the main channel between the No. 5 and No. 6 winzes. The occurrence, which is undoubtedly exceptional, has added to the original estimate of reserves at No. 6 level. Values too were equal to expectations, 1,125 tons of ore broken on the western side having produced 15 dwt. 12 gr. of gold per ton.

"There is an absence in the bottom workings of siliceous ironstone, which comprised about 2 feet of the lode resting on the footwall for fully a depth of 200 feet below the commencement of the sulphide zone.

. . . .

"Sufficient work has not been done at the 700-foot level to justify an expression of opinion as to the magnitude and importance of the ore body now being developed. The ore channel was exposed in the 700-foot plat, and the drive continued on the eastern wall and bend of the trough a length of 804 feet. The length of profitable ore in the eastern channel at this level is 254 feet. The ore was encountered 550 feet north of the shaft, and continued to the end of the trough. A cross-cut west has been commenced for the purpose of intersecting and proving the width and value of the western leg. The indications on the western side during the extension of the drive were most favourable. Numerous heavily-mineralised quartz veins were exposed. These

* Annual Report, 1912, p. 93.



Eastern Limb of Lode and Western Drive at their intersection on No. 5 Level, Mount Boppy Mine.

Mount Boppy Gold Mine. Taylor Shaft and Treatment Plant.

veins left the west side of the main east channel at an angle of about 25 degrees, and will probably form the west channel nearer the north end of the trough."*

"The rainfall during the year has been 9·64 inches, a decrease of 10 inches compared with the preceding year. From December, 1911, till June, 1912, practically no rain fell, with the result that the mine tank was empty and crushing ceased in the month of April. The mine tank is now full of water, and, considering the enlargement, there is no anxiety as to future requirements.

"Advantage was taken of the tank being empty to enlarge the holding capacity, and about 10,000 cubic yards of material were excavated. This work was in progress when the rain came."

Since the preparation of the present report additional information has been supplied by Mr. Inspector T. S. Oldfield, being an adaptation from his report for 1913 to the Chief Inspector of Mines:—

During the year the mine produced 64,762 tons of crude ore for a return of £106,991 value in gold, the ore being obtained mainly from Nos. 4, 5, and 6 (sulphides), and between 1 and 2 levels (oxides). Development work has proceeded satisfactorily, the ore reserves being, approximately, 250,000 tons. The mine was deepened to the 800-foot level . . . the lode at No. 5 level has been discovered in a north-westerly direction behind the supposed trough for a distance of over 150 feet of good width and value. . . . With this in view, the prospecting was commenced on the western side of No. 4 stope, with the result that a similar discovery has been made. . . . The new slimes plant has been giving excellent results.

The total returns from the commencement of operations by the Mount Boppy Company to the end of 1913, so far as is known in this office, are supplied in the accompanying table.†

The dividends paid by the company to the end of 1912 totalled £419,582, representing a return to the shareholders of 356 per cent.

GOLD Returns of the Mount Boppy Gold Mining Company, Limited, from 1901 to December, 1913.

Year ending—	Quartz crushed.	Tailings treated.	Slimes treated.	Gold won.	Amount realised.
	tons.	tons.	tons.	oz. fine.	£
31 December, 1901 (7 months)	12,440	7,695	....	4,421	18,781
31 ,, 1902 (6 months)	10,697	6,565	3,873	5,700	24,211
31 ,, 1903	29,312	20,783	9,347	18,769	79,724
31 ,, 1904	36,378	23,831	10,091	21,532	91,460
31 ,, 1905	51,878	33,902	15,260	27,411	116,434
31 ,, 1906	72,976	44,594	25,606	29,654	125,961
31 ,, 1907	76,330	46,134	29,925	31,339	133,121
31 ,, 1908	60,204	33,862	20,256	33,866	143,855
31 ,, 1909	70,333	45,534	21,834	28,473	120,944
31 ,, 1910	78,890	56,867	27,485	30,999	131,675
31 ,, 1911	74,132	48,132	26,845	26,194	111,264
31 ,, 1912	53,990	28,520	25,464	17,305	73,506
31 ,, 1913	64,762	.....	... .	25,209	106,991
Totals	691,331	416,535	266,289	300,872	1,277,927

* Directors' Report, 1912, pp. 34, 35 and 37. † Annual Report, 1913, p. 11.

Development.

The mine is worked mainly from two shafts (Plates II and XVII) 1,200 feet apart, and known as the Taylor and Henry shafts. Of these, the former is the older, but the latter the deeper one. The upper levels are worked from the Taylor or northern shaft, and the deeper ones from the Henry or southern shaft.

In the accompanying description of the mining workings the measurements given are approximate only, and have been taken from the longitudinal or orthogonal projection supplied by the Company (August, 1913), and reproduced herewith at 80 feet to the inch. The measurements need to be slightly modified, owing to later development work.

The northern shaft is about 160, Taylor shaft about 420, and Henry shaft about 811 feet deep.

The eastern, or main, leg is worked by eight levels known as the 100, 200, 300, intermediate, 400, 500, 600, and 700 feet levels, the intermediate being about 65 feet below the 300-foot level. Their lengths from the surface to the 700-foot level, respectively, are approximately 1,840, 1,240, 1,440, 180, 1,120, 820, 765, and 680 feet.

No. 1 level, as driven on the western leg, is about 560 feet in length; No. 2 and No. 3 levels, where driven on the same leg, are about 375 and 400 feet respectively.

A long crosscut has been put out from Taylor shaft at a depth of 300 feet from the surface to test the country east and west of the lode. The approximate length of the crosscut is 1,540 feet. Two crosscuts connect the eastern and western legs at the 100-foot level, one about 300 feet south of the northernmost point of the centre country, which is about 125 feet in width measured between the two legs; the other crosscut, about 560 feet south of this northernmost part, is 120 feet in length between the two legs. A constriction for the centre country is indicated on the 200-foot level at a point about 260 feet south of the inner edge of the trough, where the crosscut connecting the legs is 75 feet in length measured between the limbs of the lode. A crosscut also connecting the legs on the 300-foot level at an approximate distance of 240 feet south of the inner portion of the saddle keel is about 115 feet in length.

The main winzes are seven in number and are practically continuous from the surface. All have been put down on the eastern leg. They are numbered 1, 2, 3, 4, 5, 6, and 7 in order as from north to south, and are approximately 360, 360, 400, 500, 610, 750, and 500 feet in depth.

Country.—The rock association in this famous lode is of rather simple nature, consisting of well-cleaved slate, forming a hanging wall, and of a series of powerful and cross-bedded sandstones as a footwall. Excellent studies of the excessive crumpling to which the slates and sandstones have been subjected are to be found in the long crosscuts which have been put out normally to the strike of the lode. Plates XVIII, XIX, and Figs. 5 and 7 are especially instructive in this connection.

The Lode.—From the viewpoint of genesis the Mount Boppy lode is one of the most interesting in the State. It has been described by Mr. J. B. Jaquet,* Chief Inspector of Mines, a copy of whose report is reproduced on pages 53, 54, and 55. It appears to owe its origin in part (see pp. 58, 59 of

* Annual Report, 1905, pp. 69 and 70, with plans and sections of the lode.

MOUNT BOPPY G.M.Co.

PLAN OF WORKINGS

Taken from Mine Manager's Plan
A.J.S.

SCALE 0 40 80 120 160 FEET

TRANSVERSE SECTIONS

Scale 0 80 160 240 320 Feet

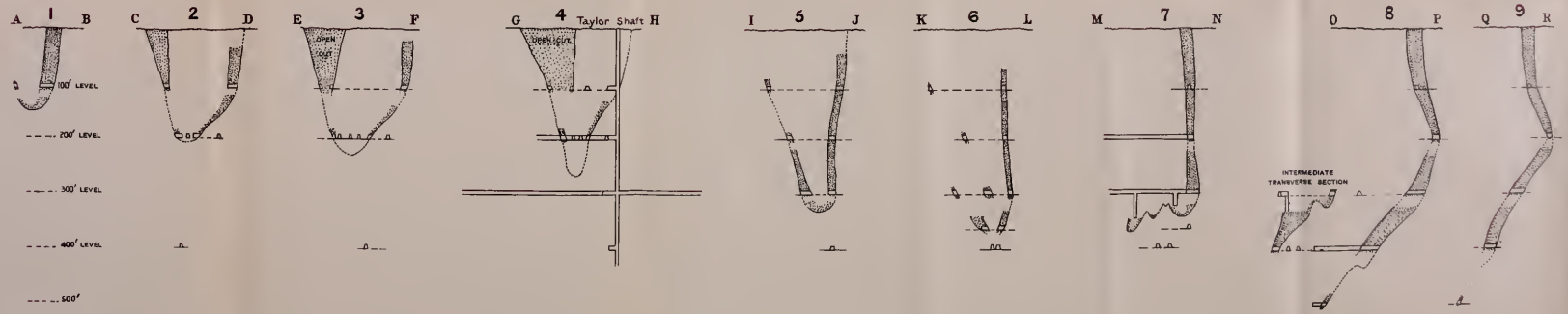


PHOTO-LITHOGRAPHED BY W. A. GULLICK

MOUNT BOPPY G.M.Co. LT.

PLAN OF WORKINGS

Taken from Mine Manager's Plan
24.5.13.

SCALE 0 40 80 120 160 FEET

TRANSVERSE SECTIONS

Scale 0 80 160 240 320 Feet

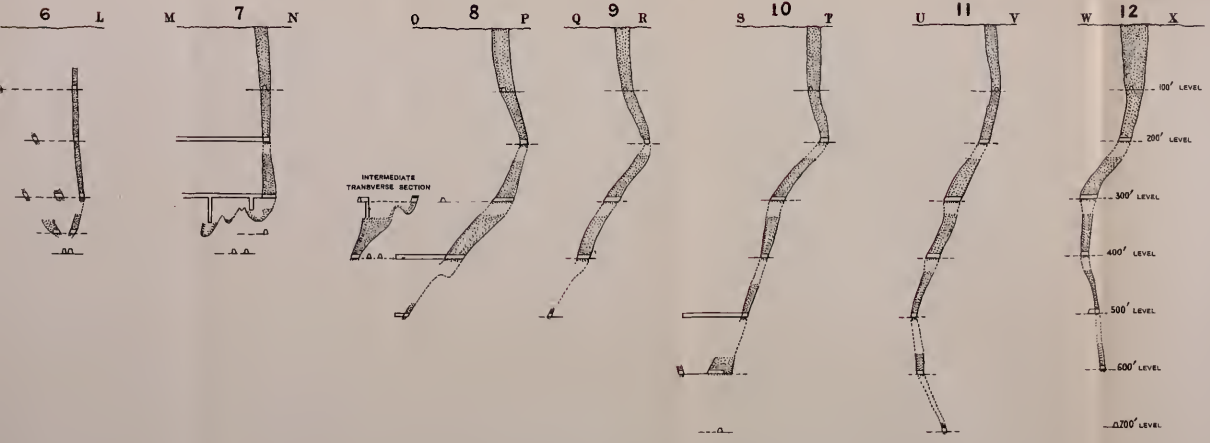


PHOTO-LITHOGRAPHED BY W. A. BULLICK, GOVERNMENT PRINTER, SYDNEY, N.S.W.

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No. 4

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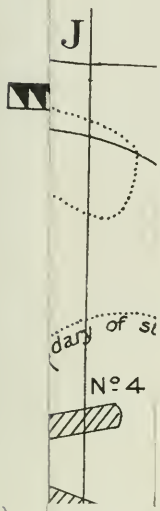
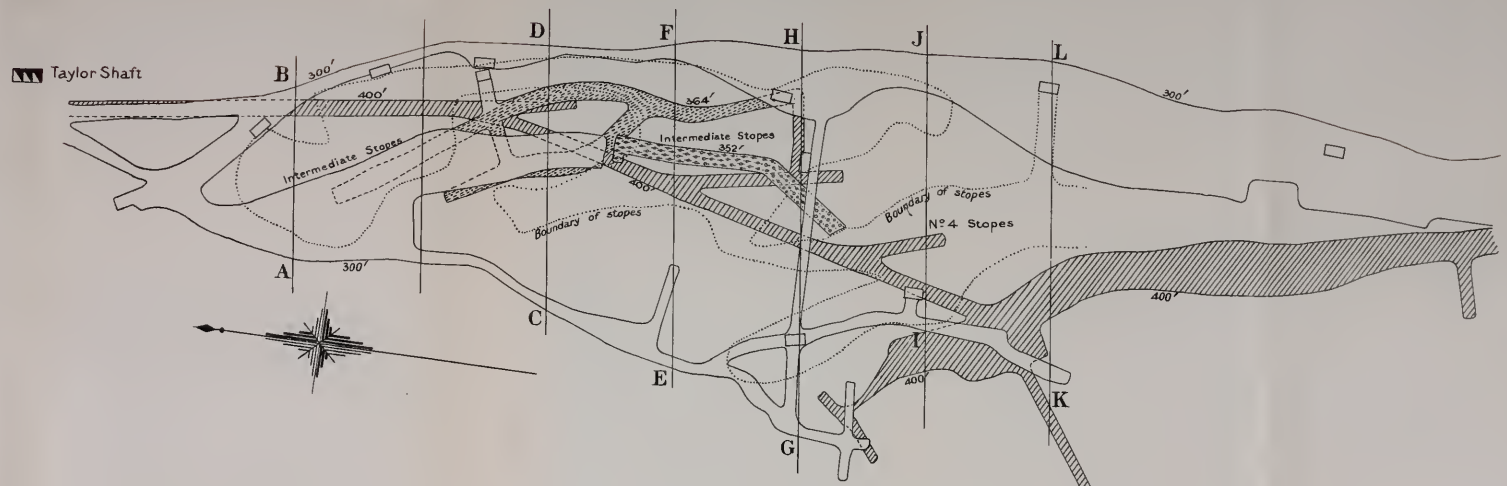


MOUNT BOPPY G. M. Co

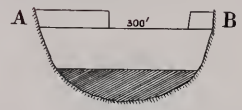
PLAN SHEWING INTERMEDIATE AND No. 4 STOPES

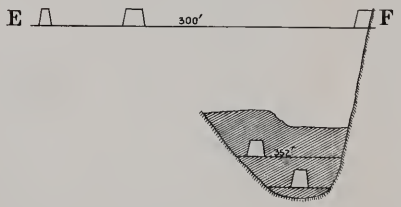
Scale 0 20 40 60 80 Feet

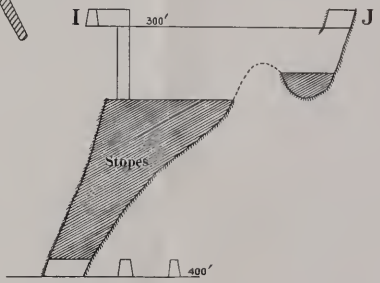
Taken from Mine Manager's plan. 5. 7. 15.

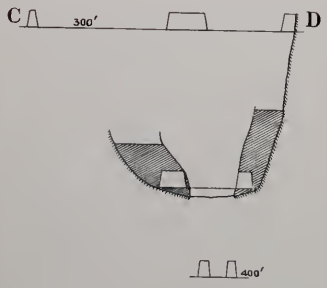


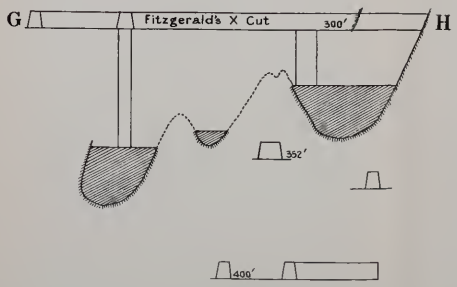
TRANSVERSE SECTIONS











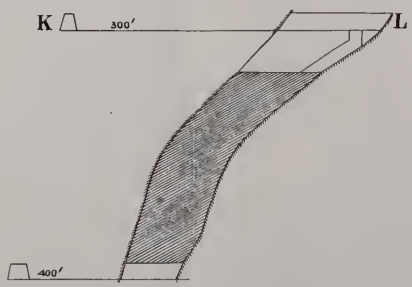


PHOTO-LITHOGRAPHED BY W. A. GULLICK, GOVERNMENT PRINTER, SYDNEY, N.S.W.

the present report) to the filling of an open fissure or a series of small associated fissures, but in great measure also to the replacement of slate (and sandstone) in the vicinity of such fissures. The phrase "saddle enlarged by replacement" would describe its nature.

The lode has a general strike of a few degrees west of north and east of south, and it has been proved for a length of nearly 2,000 feet above the 100-foot level. This measurement, however, applies only to the eastern limb, the western member being insignificant as compared with the other.

The various cross-sections supplied by the management illustrate the nature of the corrugations which have been imposed upon the primary or secondary folds in the slate and sandstone comprising the country, nevertheless such sections take but little cognisance of the smaller puckerings which have affected the corrugations in turn. The apparent puckerings shown in sections 7 and 8* are really corrugations of a secondary or tertiary order, and thus only less important than the one in which the lode has been deposited as a whole. The puckerings of the country cannot be studied to advantage, however, within the limits of the lode itself, owing to the slightly irregular replacement which the slates and sandstones have suffered. Attention will be directed to this point on a later page.

The transverse sections are numbered as from north to south, but the observer is assumed to be looking through the plane of each section in a direction as from south to north; thus the eastern limb is the right-hand member in all the examples. The sections themselves have been selected at intervals of 100 feet, and by a study of such sections the vertical axes of the corrugations (as shown in the transverse sections) may be seen to be displaced with respect to each other.

From No. 1 to No. 3 sections the corrugation simply becomes gradually deeper, and departs but slightly from a symmetrical form about a vertical axis. On section 4, the western limb is ill-defined, the eastern one well-defined, and a marked contraction of the corrugation is evident both near, and below, the 200-foot level, while the section exhibits almost complete symmetry about its vertical axis.

On section 5 the trough and eastern limb are well defined, and the western limb is also represented. The longer axis of the section, however, has been displaced as much as 20 degrees from the vertical to the east. The amount of angular displacement of the longer axis of the lode (or corrugation), on section 6, is practically the same as for section 5; but the depth of the trough has increased to 360 feet below the surface, and the eastern limb, instead of bending inwards to the west, presents a distinct convexity to the east. By this alteration of the form the distances separating the limbs of the lode have also varied.

Transverse section No. 7 is very interesting. The depth of the trough from the surface is about 370 feet at this spot, the main axis of the section is almost vertical, and is nearly parallel with the eastern limb. It is around the trough itself, however, that the greatest interest centres. The corrugation here is not simple, but complex, being split up into three distinct curves. There is nothing in this feature, however, to suggest a modification of the saddle theory of origin for the lode; on the contrary, it is rather a consequence to be expected on the assumption of such an origin. The hypothesis of saddle reefs simply requires the general conformity of the plane of the lode to the curvature of the bedding planes of the country. If the corrugations in the country be accompanied by corrugations of a lesser order of

* See Plan of Workings, Mt. Boppy G.M. Coy. (facing p. 70).

magnitude, it is only reasonable to expect that the lode itself should follow these complexities of curvature. It is evident that the sediments at this portion of the trough have been severely compressed, and have assumed this form of a complex curve in the attempt of the surrounding rock mass to occupy a minimum of space.

The section on line 7a, taken 50 feet from No. 7, shows the complex curve of the trough as it unrolls itself a little to the south, while on line 8 the curve of the trough in section has practically returned to its simple form, with the exception of a kink on the eastern limb between the 400 and 500-foot levels. In this section the corrugation proper is decidedly asymmetrical, the longer axis being inclined towards the west at an angle of about 30 degrees to the vertical. A great convexity facing the east is also present on the eastern limb between the 100 and 400 foot levels.

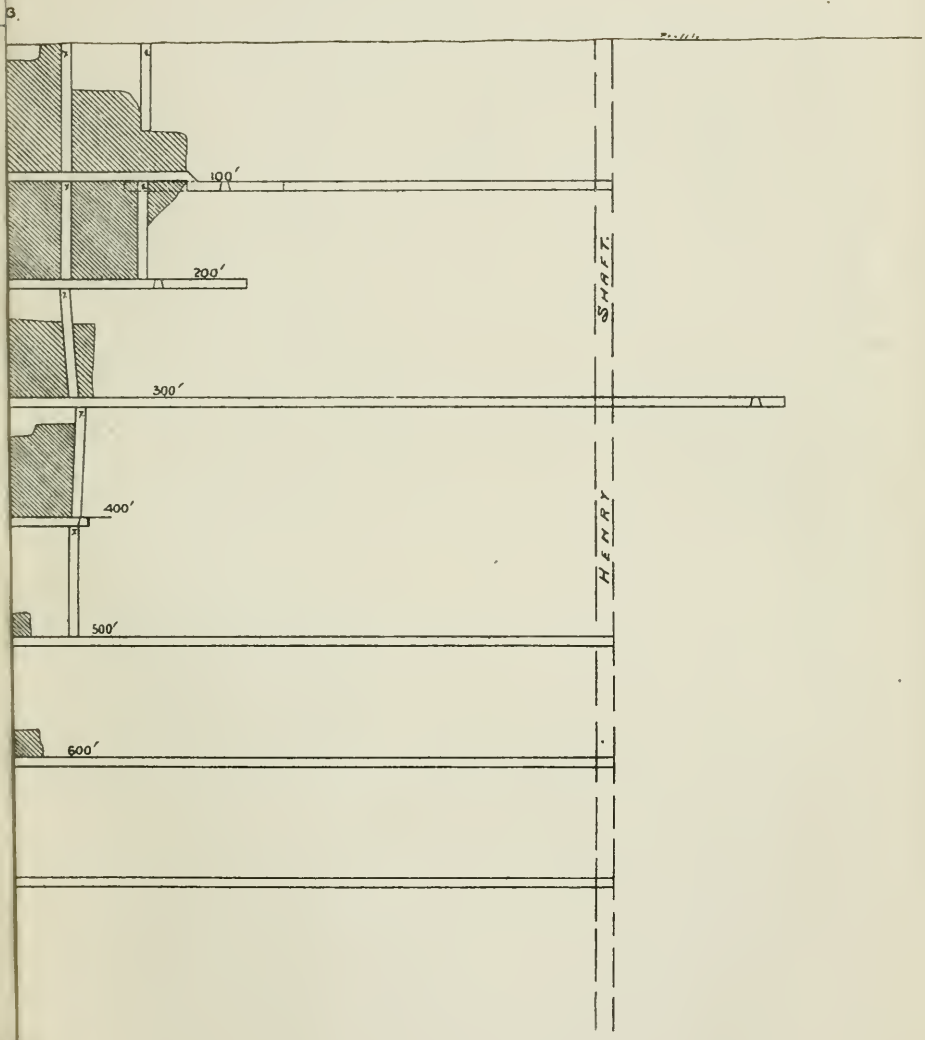
A careful study of the intermediate workings herewith produced, both in plan and sections, would well repay the student of saddle reefs, inasmuch as both the peculiarities of the trough of a lode such as the Boppy, and the difficulties attendant upon its exploitation, must be obvious upon even a casual examination of the numerous and excellent plans and sections supplied by the management. The ordinary gold-miner is accustomed to work in bodies of quartz approximately tabular in shape, with well-defined walls, and not in deposits presenting all manner of variations of inclination to the vertical within short distances. Thus the trough of an inverted saddle of irregular form presents many awkward problems to the management.

Until the nature of a lode, such as that under consideration, has been ascertained, the miners cannot rid themselves of the idea that the lode is a fissure which has been faulted, with subsequent enlargement, and enrichment, of the vein along the plane of slipping. Especially is it difficult to free the minds of miners and prospectors from this idea when the evidence of massive breccias is frequent along the lode, when the western limb of the lode has been so poorly developed; and when the peculiar replacement of slate by cherty material is so common as in the case of the Mount Boppy.

Prospecting becomes difficult, especially in the earlier stages, because of inability to lay out work in advance owing to lack of knowledge of the general trend and dip of the lode. In the case of a complex trough it becomes imperative to conduct prospecting operations simply by following the quartz and carefully noting its relation to the footwall country. Whenever either a fresh winze is sunk below the deepest workings, or a new level is opened up, the possibility of trough vagaries is ever present with the management. It is only after the lode has been well opened up that work can be laid out much in advance with confidence.

On section 9 the western limb is represented. The convexity of the lode towards the east between levels Nos. 1 and 3 is still more pronounced, while there is a distinct bending to the west between levels Nos. 3 and 5. A comparison of the inclinations of the corrugation to east or west is afforded on sections 5 and 9 with that on line 7 as an intermediate and vertical stage possessing a complex or crinkled trough. The reader is referred to Fig. 5 as an illustration of the types of puckering to which the footwall country has been subjected.

On section 10 the corrugation may be seen to have reached a depth exceeding 600 feet below the surface, and its western limit has been found on the 600-foot level. The corrugation appears to have straightened itself somewhat, but the convexity to the east already noted between the Nos. 1 and 3


B.
100'
200'
300'
400'
500'
600'
SHAFT.
HENRY

M' BOPPY G. M. Cº. Lᵀᵈ.

LONGITUDINAL SECTION

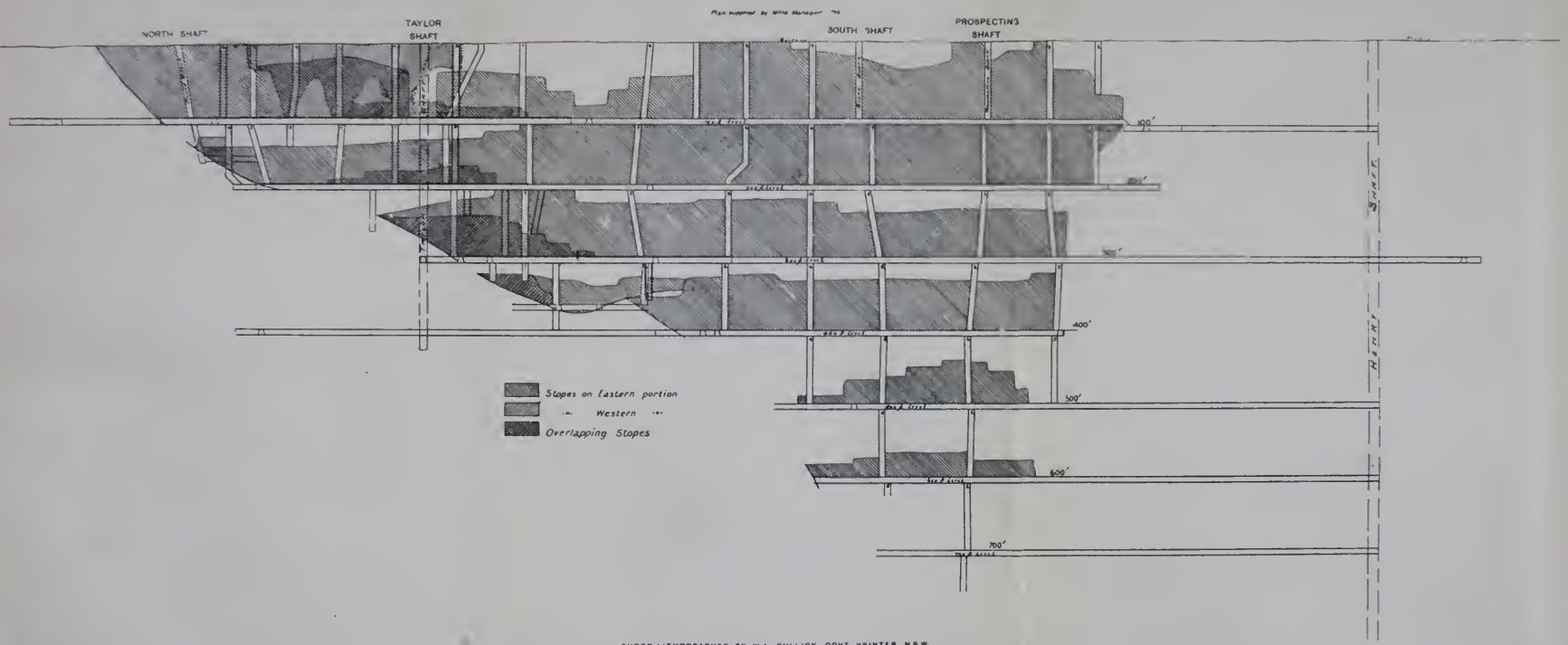


PHOTO-LITHOGRAPHED BY W.A. GULLICK, GOVT. PRINTER, N.S.W.

levels is still important, nevertheless it appears to have diminished in a decided manner.

From the 300-foot level to the trough the dip of the corrugation is fairly regular, and in a direction towards the west.

A strange transformation is evidenced in the transverse section, No. 11. Here the trough attains a depth greater than 700 feet. The convexity of the corrugation to the east, which is such a prominent feature, in sections immediately to the north, has here diminished to a bulge of moderate dimensions only at the 100-foot level, while a large and important convexity has resulted, causing the whole of the lower 500 feet of lode along this section to bulge decidedly to the west. It is evident that when the western limb shall have been found the whole section will present an appearance strikingly asymmetrical, and with its longer axis inclined strongly to the east.

Sections 11 and 12 are similar, but the convexity to the east at the 100-foot level is still less important than as represented at 11, while the convexity to the west extends from the 200 to a point below the 700-foot level, and is becoming emphasised at a depth of from 250 to 400 feet below the surface.

A model of the lode based both upon the transverse and longitudinal sections of the mine, and the evidence of various crosscuts, would give the idea of a corrugation possessing a rude form of symmetry about a vertical and meridional plane near its northern or shallow portions, but a marked lack of symmetry along the greater portion of its length, the main axis of the form having a slightly curved, although meridional trend in general aspect, but a marked oscillation of the figure from west to east and from east to west about a vertical line considered from point to point along the length of the lode.

Although the form of the lode as worked is thus strongly suggestive of an inverted "saddle" in general aspect, it will be advisable to advance other evidence in support of this contention.

With this idea in mind, a careful examination of all crosscuts, drives, stopes, cuddies, and other accessible workings was made. In this work the writer was somewhat fortunate, because of the long crosscuts which had been put out into the country by the management for the purpose of finding the continuation of the lode at one time supposed to have been faulted heavily along a plane passing through what is known to be the enlargement of the lode as mentioned by Mr. Jaquet.

The narrative method is here adopted as affording a simple presentation of the case.

At the outset it was noted that the rocks of the locality appeared to be schistose in appearance, and it became necessary to ascertain whether this appearance was due to mineralisation along bedding planes or to structures formed during a later period. A search throughout the railway cuttings near Canbelego proved beyond doubt that such structures were due to the presence of the bedding planes, and that the latter phyllitic or schistose appearance exhibited by many rocks in the mining area was due to a development and arrangement of minerals parallel to these bedding planes. This was ascertained by an examination of the sediments at their planes of junction with others of varying texture and character.

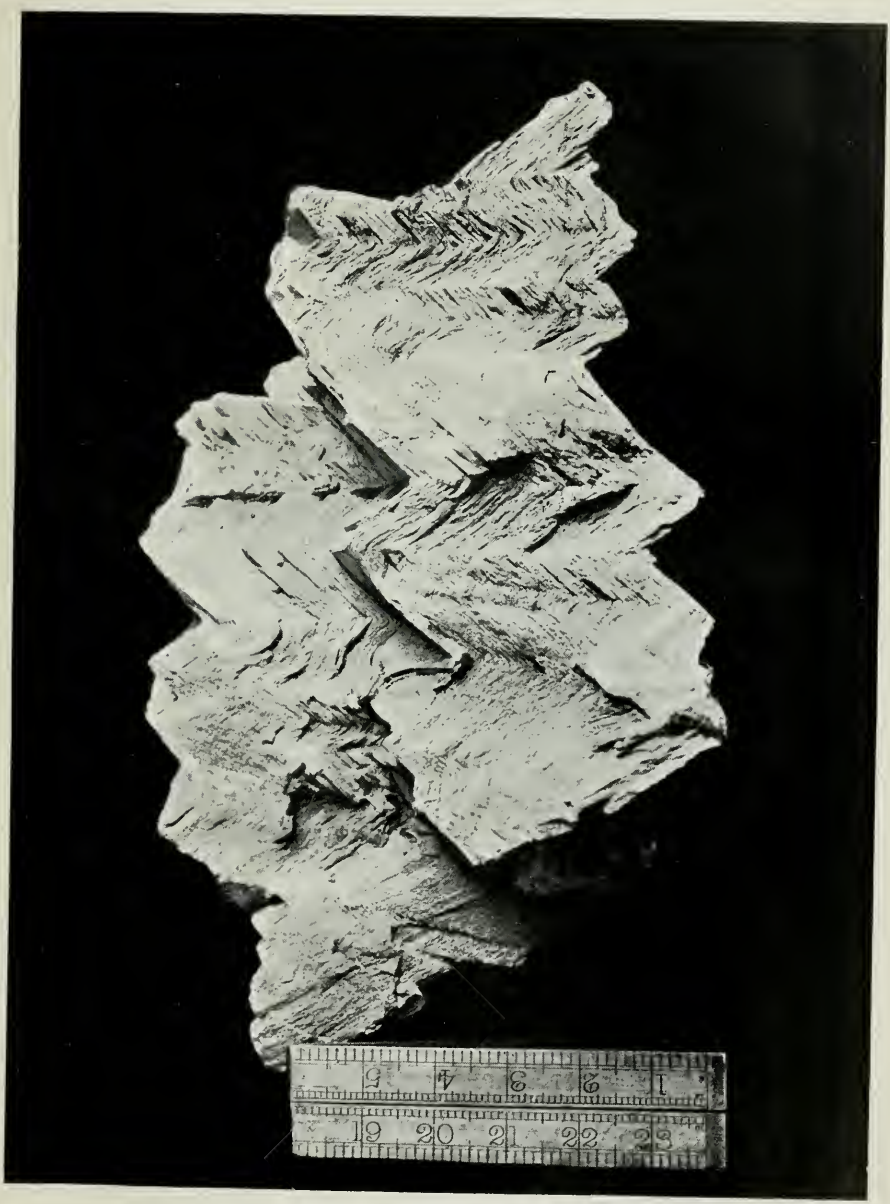
The examination of the more readily accessible workings at the outset appeared to throw doubt upon the saddle origin of the lode. Thus in the open cut on the western portion of the lode at the northern end of the mine, the ore deposit was observed to form a network of stringers throughout the

slates. In the crosscuts on the 300-foot level, also, the slates were observed to be well cleaved and jointed, but the bedding planes appeared to dip west wherever observed in these openings. Not only so, but the western lode was seen along Nos. 1, 2, and 3 levels to have been split up into small veins and stringers, some of which followed the bedding planes, while others transgressed these surfaces. Figs. 4*a*, 4*b* illustrate these points. Furthermore, it was noted along the levels, in the oxidised zone, that structures which appeared to be well bedded, were so arranged as to suggest the amount of inclination between the dips of sediments and the lode in contact to be as much as 30 or 40 degrees. Thus in the northern end of the large stope on the trough at the 200-foot level the actual plane of contact between lode and country appears to dip towards the observer at a low angle, whereas the country may be seen to be strongly crumpled, the value of the dip varying from 35 to 70 degrees. Even upon casual inspection it was evident that the general plane of the lode was not at all parallel to the inclination of these crumpled sediments. Similar phenomena were noted right along the western wall of the western body.

A careful examination of all workings which occur at points farthest removed from the lode was then undertaken inasmuch as the lode itself was undeniably in the form of an inverted saddle. The first point to be clearly ascertained from an examination of crosscuts and other workings was that the country lying between the main limbs of the lode was invariably a dark slate, but that the footwall or outside country consisted of a mixture of sandstone and slate, the former preponderating in amount, and constituting a very heavy or powerful series immediately alongside the lode; in other words, it was ascertained that the lode proper lay between a mass of slates and sandstones, and that this obtained for both eastern and western walls.

This feature was observed along all levels, whether existing above or below water-level.

An examination of the crosscuts on No. 1 and No. 2 levels also revealed the fact that the sandstones formed a powerful series which in places were crumpled and puckered, but which, in other places, appeared not to have suffered so much from compressive agencies. The massive sandstones were found to possess other divisional planes which presented a general parallelism to the lode. These were suspected to be true bedding planes, and a search was therefore instituted along the more important crosscuts, such as that which had been put in to the east towards the south end of the workings on the 100-foot level and that extending for nearly 1,500 feet opposite Taylor shaft, on the 300-foot level. Following that portion of the latter crosscut which had been put in west of the lode, the massive sandstones underlying the lode were observed to be strongly crumpled and puckered, but at a considerable distance along the crosscut the sandstones were found to alternate with black slates. Nevertheless, the apparent bedding planes of the sandstones were observed to be strongly inclined to the plane of contact of sandstones with slates. The slates were highly cleaved, but their bedding planes were obviously parallel to their planes of contact with the sandstones. The apparent bedding of the sandstones was thus seen to be only a false or cross-bedding. This feature is well illustrated in the sketch section shown on page 75. The finest puckering of the cross-bedded sandstones was obscured from 500 to 700 feet west of the shaft. Owing to the kindness of the management large specimens illustrative of these structures were secured, which may now be seen in the Mining Museum at Miller's Point, the Technical College of Sydney, and the various State Universities.



Puckering of Cross-bedding Planes in Sandstone, Mount Boppy Mine.
Western Crosscut, No. 3 Level, 500 feet in crosscut.

Puckered Crossbedded Planes in Sandstone from Western Cross-cut, No. 3 Level, Mount Boppy Mine.

An examination also of the centre country revealed the fact—in the cases where the dip of the centre country slates is practically uniform—that the saddle is asymmetrical at that point, and that both limbs dip in the same direction along the small area considered. Fig. 6 illustrates this point.

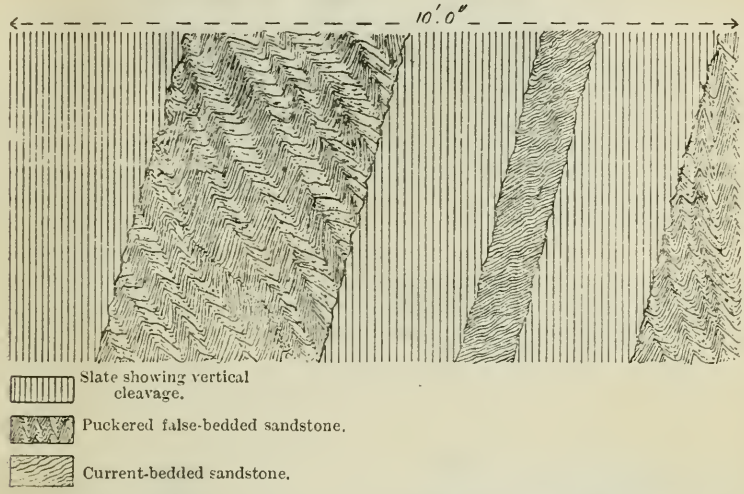


Fig. 5.—Sketch of slate and sandstone association, about 600 feet from Taylor Shaft in No. 3 Crosscut West.

The variable effect of compression may be noted by a comparison of the three sandstone belts.

Further examination showed the eastern limb to be a persistent feature, and that it was tightly wedged in between the sandstone and slate country, but that the western limb was much less persistent, and that it followed the bedding planes only in certain places, breaking across them in others as veinlets or as networks of stringers without sign of definite lode, and that it died away into the country as veinlets partly following the bedding planes and partly following the cleavage or other joint planes. To this peculiarity of the lode further reference is made on a later page.

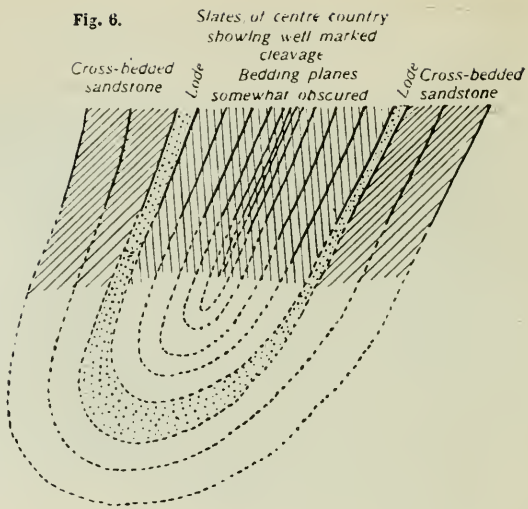
Additional Notes on the Lode.

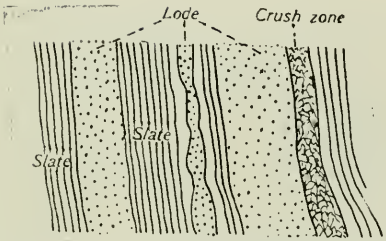
(1) *The Pitch of the Trough.*

As measured from the plan supplied to the Department of Mines by the management, the pitch of the lode trough to the south, exclusive of displacements to east or west, may be inferred from the following facts:—

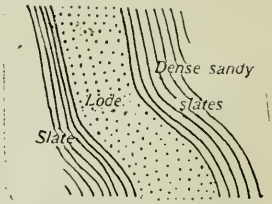
The northernmost workings along the trough at the 200-foot level are about 110 feet south of those on the 100-foot level. From the 200 to the 300 foot level the advance of the trough to the south is about 280 feet, while from the 300 to the 400 foot level it is about 260 feet. The advance south from the 400 to the 500 foot level has not been definitely ascertained, but from the 400 to the 600 foot it is about 180 feet, or an average of 90 feet advance south in sinking each 100 feet between these levels. From the 600 to the 700 foot level the advance southerly of the northern point of the trough is about 80 feet.*

* Since this note was written, Mr. Negus and Mr. Polkinghorne have ascertained that the workings along Nos. 5 and 4 levels have had to be carried much farther to the north, so that the trough has a steeper pitch to the south than had been considered at the time of writing the above note.





Detail of structure on eastern limit of Boppy Lode. Upper levels.



Detail of structure on eastern limits of Boppy Lode. Upper levels.

(2) *The Distribution of the Commercial Ore.*

(*a*) *Eastern Limb.*—Near the surface the stone has been removed for a length of about 1,350 feet, as measured along the lode. The lengths of the ore as exposed in a continuous body along the eastern limb on Nos. 1, 2, 3, 4, 5, and 6 levels are approximately 1,300, 1,125, 820, 520, 340, and 300 feet respectively. The length measured along the No. 7 level is comparable with that found along No. 6 level.

(*b*) *Western Limb.*—A study of the workings on the western limb leads to the conclusion that the western limb is much less important, as an ore producer, than the eastern one. An examination of the longitudinal section accompanying the report illustrates this point and shows, moreover, how the ore body, to the west, disappears rapidly with increasing distance from the trough.

(*c*) *The Trough.*—This portion of the mine has been almost consistently a producer of good ores besides being important from the point of view of tonnage.

Generally speaking, the trough has formed the mainstay of the mine, and the commercial value of the limbs of the saddle appears to be intimately related in some manner to the trough.

Evidence of Prospecting Operations.—In addition to the productive mining operations, much dead work has been accomplished within the Canbelego township area, and the evidence derived from a study of such work is not without its significance in connection with the question of the probable lines along which future development may be expected to take place. These and related points may be touched upon briefly at this juncture.

In the early days of Mount Boppy mining the prospectors came upon the trough, and, as already stated, such trough was considered by them as an indication of a heavy fault. In consequence, long crosscuts were put out into the country from the upper levels, and the results thus obtained were such as to prove, beyond all doubt, that the lode is a peculiar type of saddle lode, being of inverted nature and due, in great measure, to replacement agencies. Not only so, but such work failed to disclose the existence of other and parallel saddles.

At different times, long crosscuts have been put out from levels, or shafts, of varying depths, both to the south and north of the main Mount Boppy workings, and in such directions as to prospect the ground at right angles to the general strike of the eastern or main limb of the Boppy lode. The more important of these crosscuts are indicated on the accompanying map of the Canbelego township.

All such prospecting openings have failed to reveal payable continuations of either the Boppy or other possible lodes. On the other hand, however, the prospecting does not appear to have been of a character best calculated to reveal the presence, if existent, of other and subparallel lodes. Reference to this will be made on a subsequent page.

There are several other interesting points which appear to have a bearing on the future development. In the first place it was noticed at the Henry shaft, and for a distance of from 300 to 400 feet in a direction northerly from that point, that the lode channel of the eastern limb was well defined and almost vertical, but that it appeared to be pinched and tight, while at a certain distance from the shaft the lode became stronger and richer. Along all the levels cleaved black slate formed the western wall of this limb, while the eastern wall wherever observable was of sandstone.*

In the second place, the trough may be observed to have undergone certain modifications with increased depth. Thus at the 200-foot level it has become decidedly contracted in width, and the replacement was very decided, while above this the spreading apart of the limbs was accompanied by the formation of a network of stringers on the western limb, suggestive of an inability thereby to form large bodies of replacement in this direction. In transverse sections Nos. 8 and 9, shown on the accompanying map supplied by the management, the contraction of the lode towards the base is marked, nevertheless from the surface to this point the average pitch of the lode is only moderate, the advance south being as much as 550 feet in a depth of 375 feet. Thence in a southerly succession comes the important "Intermediate level," with its broad and corrugated trough. Beyond section No. 11 the trough pitches very steeply, and at the same time the limbs become well separated with a suggestive diminution of the western member. At No. 5 level the nose of the trough apparently has not been definitely determined although the lode has been carefully examined

* This is an argillaceous type of sandstone.

in company with Mr. Polkinghorne with this point in view. In No. 6 level the replacement body is very large, while at No. 7 the nose has not yet been satisfactorily determined.

Crosscuts have been put out from the 400 and 500-feet levels near the nose of the trough in such localities, the former about 90 feet in length to the south-west, and the latter about 110 feet to the west. These still appear to be in slates and therefore, probably, have not reached the western limb, if the western limb indeed extends to that distance. It would thus appear that the trough has steepened, and widened, below the intermediate stopes.

In the third place the lower levels show that the trough has not only become broader, but it is so developed that it presents a great convexity to the east inasmuch as that, whereas the more southern portion of the eastern limb conforms to the general strike of the lode, nevertheless from levels Nos. 3 to No. 6 the nose of the trough has been swung strongly to the west.

In the fourth place it may be noted that the ore shoot appears to be bounded, on the south, by a vertical plane arranged east and west to the depth, at least, of the 700-foot level.

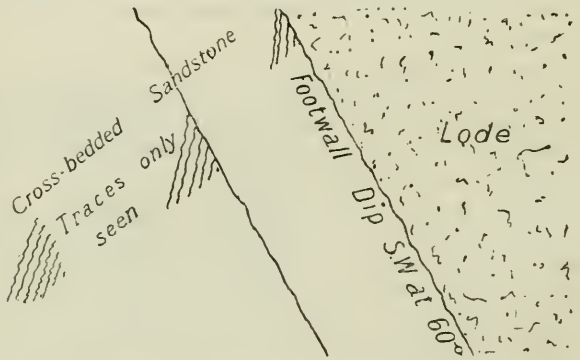


Fig. 7.—Sketch of detail of Mt. Boppy Lode in the vicinity of Taylor Shaft, No. 3 Level.

Another point which merits consideration in this connection is the mineral association of the lode. The management regards the presence of zinc-blende as a favourable indication for gold values in the Boppy Mine, and stopes which possess a decided zinc-blende content were pointed out to the writer as valuable ore bodies. The presence of this zinc-blende in the relative absence of galena is suggestive of a secondary origin for the mineral, and it becomes a matter of importance to understand to what depth such bodies of zinc-blende will continue. From an examination of the lode in detail it is probable that these zinc-blende contents will continue for considerable depths below the deepest levels yet reached in the mines owing to the general appearance of the eastern side of this lode, and the crushing and consequent percolation which has taken place subsequently to the formation of the ore deposit proper. We may, therefore, dismiss the possibility of the zinc-blende* diminishing in importance in depth and confine ourselves to the question of structure in the consideration as to the lines along which future development may be expected to take place.

* In Broken Hill the zinc-blende occurs in mass at the deepest levels yet known.

An analysis of the sulphide ore from the deeper levels is here reproduced. The gold contents have not been estimated. The stone was obtained, however, from one of the richer portions of the mine:—

987. Picked Sulphide Ore from Mount Boppy Mine.

SiO_2	61·08
Al_2O_3	2·81
Fe_2O_3	2·50
FeO	0·09
MgO	0·63
CaO	1·06
Na_2O	0·56
K_2O	0·91
H_2O (100° C.)	0·12
H_2O (100° C.+)	0·48
CO_2	0·53
TiO_2	0·01
ZrO_2	absent
P_2O_5	trace (less than 0·01 per cent.)
SO_3	absent
Cl	trace (less than 0·01)
FeS_2	3·76
ZnS	17·68
PbS	7·98
CuS	0·08
MnO	0·02
Cr_2O_3	absent
NiO + CoO	
BaO	
SrO	
Li_2O	
V_2O_3	
	100·30
Specific gravity ...	2·994

Analysis by H. P. White.

It is here suggested that the non-payable character of the portion of the lode in the neighbourhood of the Henry shaft is dependent, in the main, upon its vertical nature at that locality. The walls in this case have simply approached each other in parallel planes, and have suffered very little relative motion. Compression, and not tension, at right angles to the bedding planes, has been, therefore, the net result of this movement, and uprising solutions would experience difficulty in effecting an entrance to such compressed areas. On the other hand, both along the trough, and especially in areas, where the pitch of the trough changes rapidly, the laminæ of the slates and the cross-bedded sandstone layers would tend to be separated by tension, and these would be more readily accessible to wandering solutions, and thereby be rendered more amenable also to replacement.

In brief, then, the lode appears to be almost vertical and tightly compressed along its southern portion, as prospected, while along its northern portion it is irregular both in plan, transverse action, and in longitudinal section.

In connection with this point, it is instructive to note that a study of the scattered outcrops and the rock exposures in the infrequent railway cuttings indicates the very irregular and the close nature of the folding in the Canbelego district. Corrugated and puckered folds are characteristic, the corrugations frequently attaining a large size.

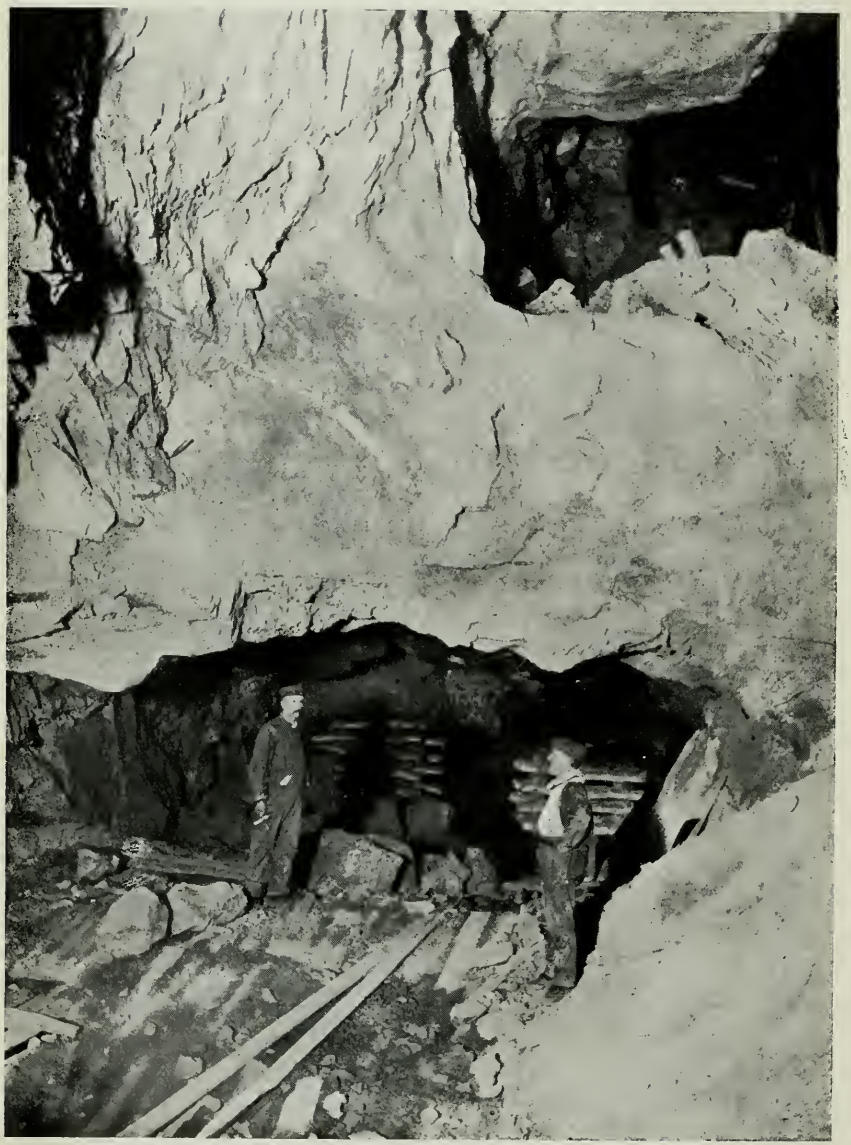
An application of this knowledge to the case of the Boppy lode suggests that the regular dip of the southern portion of the eastern limb is a local

feature only, and that it may be expected to be found to be irregular at any point beyond the present workings, and that the trough may also flatten and become corrugated. A study of the lode also suggests that the slates and sandstones along the western limb are strongly compressed, and that the penetrating power of the mineralised solutions had been rapidly dissipated in that direction. The ore developed and mined up till the present appears to have depended, in great measure, upon a physical disturbance, namely, the swinging of the sediments from a regular into a very irregular fold, and it is highly probable (as suggested by a study of the field) that such regularity of lode as shown near the Henry shaft, may be found to give place to marked irregularity in general form at lower levels. Such an expectable result would be almost sure to be accompanied by large tonnages of ore.

It must be understood here, however, that although the writer has made a careful study of the locality, with the idea in view of the exact nature along which prospecting operations should be undertaken, nevertheless he has been enabled only to arrive at the general principles stated in the previous paragraph. For example, the strike of the *corrugation* itself south of the Henry shaft has not been ascertained even, because, in the first place, the area is covered for a long distance with alluvium and waste; and in the second place, the prospecting shafts and crosscuts south of the Henry shaft have been inaccessible to the writer. A careful examination of even such crosscuts, shafts, and drives as are existent would help a geologist materially in arriving at a conclusion as to the probability of the corrugation under consideration being altered in form in a direction south of the Henry shaft. Even with our present information it would be impossible to state at all definitely at what distance east or west from, or the depth below, the present lowest workings, the trough might be expected to be cut, even immediately to the south of the Henry shaft. In any case, the problem is one which possesses such possibilities that it is to be hoped a company such as the Mount Boppy would not be discouraged even should the trough prove to be poor for a depth of a couple of hundred feet before the present workings, but that they would continue either the present Henry shaft or sink a new one a little to the north, to a further depth of 500 feet, thence crosscut for the slate and sandstone junction, and then follow this to the north. In such prospecting an essential condition would be the recognition of the centre country when it should have been struck. A careful study of the immense crosscut on No. 3 level off Taylor shaft would be invaluable in this connection, as the beds therein revealed may be expected to be repeated in the region of the Henry shaft. It seems hardly necessary to remind prospectors that the centre country is a strong mass of black slate.

Another point calling for consideration is the probability of the occurrence of parallel saddles in this closely folded country. The long crosscuts put in at the No. 3 level in the Boppy Mine, at the 200 and 300-feet levels at the North Boppy, and at the 500-feet level at the South Mount Boppy, have not proved the existence of bodies of gold quartz parallel to the Boppy lode. It may be pertinent, however, at this stage to raise the question as to whether the field is to be finally judged on the present interpretation placed upon the evidence of the sections exposed in the walls of the crosscuts. It is possible, for instance, that these workings have not been studied in the light of a comprehensive knowledge of the geological associations of the main lode. If the crosscuts, for example, have been driven in solid sand-

Eastern Limb, No. 5 Level, Mount Boppy Lode.



Mount Boppy Stopes, illustrating methods of winning ore.

stone, or in sandstone possessing only a few narrow bands of slate, then it would appear that the prospecting has been productive of negative results only. On the other hand, if a fairly wide mass of well-cleaved slate should have been found to occur within a setting of powerful sandstones and a vein, or series of veinlets, of quartz should have been found at the junction of the two sedimentary types, then it would be advisable, in the highest degree, to follow this cue. For in old rocks, such as those containing the Boppy lode, it would seem to be the rule, in South-Eastern Australia, to find saddle reefs repeated under similar geological associations. The Bendigo saddles, in the Ordovician strata of Victoria, are a famous example, and it is scarcely conceivable that the Boppy lode should be the only saddle in this class of country at Canbelego. The Hargreaves Field also furnishes another example of this rule.

Another point which should prove useful to prospectors is the rule employed by the Bendigo miner as regards the evidence yielded by water channels and mentioned by Mr. Dunn* in his excellent report on the Bendigo Field. "In cross-cutting dry country it is always considered a good sign, and hopeful, if water in the beds is cut, for a reef may have been formed in such a site as the siliceous solutions had access to; probably where the water is now found such solutions also circulated." In this connection it may be advisable to mention the strong flow of water in the No. 3 crosscut at its western end. This point certainly needs investigation so as to ascertain the reason for such strong inflow at this point. If a strong junction of slate and sandstone country, with either a "formation" or a quartz reef, should be revealed, then it would be advisable to drive along the course of such ore.

In brief, from a consideration of the foregoing pages, in which it is pointed out that saddle reefs in old rocks in South-eastern Australia occur together in numbers, it is highly probable that saddle reefs occur at Canbelego other than the famous Boppy reef, but that prospecting has failed to discover such bodies, due doubtless to the lack of outcrops in the locality. The possibility that the Boppy reef itself may continue payable to depths considerably greater than those yet attained appears to depend upon a continuance of the non-symmetrical form of the trough. The general lack of symmetry observed for the folding of the district is a hopeful sign in this connection.

Note on Treatment of Ore.

The new grinding and treatment plant, consisting of tube mills, Dorr thickeners, Moore vacuum filters, and air agitators, with the necessary classifiers, pumps, and other machinery is coping with the output from forty-five head of stamps, the remaining fifteen being still reserved for treatment of oxide ores.

The battery pulp, elevated by means of a centrifugal pump, passes through classifiers and conical thickeners to four tube mills, each 16 ft. x 4 ft. diameter, and driven by 25 h.p., and running at 28 revolutions per minute. The discharge from the tube mills, after passing over amalgamated copper plates, is elevated to three Dorr thickeners by means of a 40-feet tailings wheel. These thickeners deliver a product which is eminently suitable for vacuum filtration. The settlers, which are provided with these Dorr thickeners, are 27 ft. x 11 ft. in measurement, and each settler holds 6,600

* Reports on the Bendigo Gold Field, No. II, 1896, p. 25.

cubic feet of pulp. The total surface area of the three settlers is 1,800 square feet, or about 9 square feet per ton of solids per twenty-four hours. The overflow is estimated at about 1 gallon per foot per minute, and is returned by gravity to the battery supply tank. The discharge from the Dorr thickeners is run into two dewatering tanks, and the slime is dewatered by means of Moore vacuum filter baskets.

The dewatering plant consists of two concrete tanks 12 ft. x 11 ft. x 8 ft., with six 1-inch perforated iron pipes lying along the bottom, through which, when necessary, air at 8 lb. pressure may be blown to prevent the settlement of fine sands.

The dewatering filter baskets consist of two vacuum filters formed of 16 frames each 10 ft. x 5 ft. x 6 in., with a total filtering area of 1,760 square feet each. The vacuum is from 20 to 25 inches. These filters build a cake containing about 6 lb. dry slimes per square foot, or about 4 to 7 tons dry slime per basket, in forty-five to sixty minutes. The vacuum is maintained by a 14 in. x 14 in. double-acting wet vacuum pump, with a displacement of 96 cubic feet per minute. The basket with slime cake adhering will be lifted from the pulp tank by a 15 h.p. electric crane over a vortex mixer. The cakes of slime, containing from 25 per cent. to 30 per cent. moisture fall into a mixer and are mixed with an equal weight of cyanide solution. The mixed pulp is then elevated to the agitator by a treble ram pump 8 in. in diameter x 10 in. stroke. Capacity, 13,500 gallons per hour.

The agitating plant consists of four concrete agitating tanks 36 x 10 ft. These hold 30 tons of dry slime with 1½ times its weight of solution. The tanks are built of concrete, and are worked on the continuous principle. Each tank requires 25 cubic feet free air per minute at 25 lb. pressure.

When sufficiently agitated the discharge from the last agitator is run off into two filtering tanks similar in design to the dewatering tanks 13 ft. x 8 ft. x 12 ft.

The gold solution is filtered off by means of other Moore vacuum filters, of which there are three, each consisting of twenty frames 10 ft. x 5 ft. 6 in., having a total filtering area of 2,200 square feet each. The vacuum is maintained at from 20 to 25 inches, by a 14 in. x 14 in. horizontal double acting pump. The solutions extracted by the filter will be delivered to one of the present sand vats, which will be used to clarify the solution before running to zinc boxes.

Each basket will lift about 6 tons dry slime in thirty to fifty minutes, and as it will take a similar period to wash values from cake, the basket will require about two hours for complete treatment, equal to an output of 70 tons per basket per twenty-four hours. Baskets to be elevated by 25 h.p. electrical cranes.

Three wash tanks are in existence—each measuring 13 ft. x 5 in. x 7 ft. One tank, to be used as an acid tank, will be kept as a spare should the cloths become choked with lime or magnesia.

When a cake is sufficiently washed, the basket is again raised, and the vacuum maintained till the cake is dry. It is then carried to the vortex mixer, and pumped to the present dump.

The whole of the filtration plant is electrically driven, power being generated by a 90 k.w. Belliss and Morcom engine.

The foregoing account of the treatment of the Boppy ore is a summary of notes supplied by the General Manager, Mr. James Negus.

Nescham's Shaft, South Mount Boppy Mine.

The accompanying table, showing the work done by each department during 1912, has also been supplied by the company.

Distribution of Production.

Department.	Tons treated.	Bullion recovered.	Contents, Fine Gold.	Yield per ton treated.	Yield per ton milled.
				dwt. grs.	dwt. grs.
Amalgamation	53,090	9,255·05	6,8[illegible]8·226	2 13·33	2 13·33
Concentration	42	359·76	359·760	.....	0 3·20
Cyanidation Sand	22,709	6,317·88	3,873·565	3 9·87	1 10·44
,, Slime... ...	25,464	8,381·97	5,215·828	2 2·32	1 22·37
Retreatment Sand... ...	5,811	1,251·70	773,650	2 15·91	0 6·88
Totals	.....	25,566·36	17,121,029	.....	6 8·22

The average yield per ton of ore was 9 dwt. 11·30 grs. bullion, containing 6 dwt. 8·22 grs. fine gold.

Gross value at £4 4s. 11½d. per fine oz.—£72,729.

Approximate realisable value of bullion, £72,506 12s. 1d.

Realisable value per ton milled, £1 6s. 10·3d.

This new grinding and filtration plant appears to be working satisfactorily, and it is stated by the company (Directors' Report, 1912) that—

". . . already the lowest average residue obtained for many years has been produced by this plant. Changes and small adjustments are still being made, with the object of increasing its efficiency.

"A change in the composition of the ore of this mine has been noticeable during the past year or two. The upper portion of the sulphide zone contains about equal amounts of zinc-blende and sulphide of lead, but the lower levels produce a large proportion of blende. While the blende is more gold-bearing than the lead, it does not liberate the gold without fine grinding so easily as the ore in the upper levels containing about equal proportions of both minerals. Numerous tests have shown that the available oxygen in the cyanide solutions, which is absolutely necessary for the dissolution of gold, is greatly reduced by the marked increase of oxygen absorbing mineral. A number of experiments carried out by air and mechanical agitation proved that air agitation produced 15 per cent. better extraction than mechanical agitation, notwithstanding the fact that air agitation was continued one quarter the time given to mechanical agitation. These experiments were carried out under similar conditions as to volume and strength of solution. The results obtained demonstrate that the continuous flow of air through the pulp has maintained the necessary supply of oxygen in the solution used in the air agitated experiment; while in the mechanically-agitated experiments, the dissolution of gold has been retarded by dearth of oxygen, due to its absorption by reducing minerals."

South Mount Boppy Gold-mining Company, Limited.

G.Ls. 4, 5, 7, 10, 23, 27, 32, 33, 34, 35, 41, 42, 47, 48, 49, 50, 54, 55, 56, 57, and 58, parish Cohn, county Robinson; and G.Ls. 32 and 34, parishes Cohn and Geweroo.

Country of slates and phyllites, with sandstones and quartzites, strongly cross-bedded and puckered, and suggestive of schistose sediments. The South Boppy, as also the North Boppy, Hogan's Block, the Birthday, the Canbelego King, the Boppy, Birthday, and other mines, was worked with the intention of either picking up the extension of the Mount Boppy lode along a N. and S. line, or of picking up a line of lode parallel to the original Boppy line. Since the prospecting operations have ceased along the lower levels of these mines, it has been considered advisable to reproduce extracts from existing reports as to the history of these properties.

At the same time that Mount Boppy was found, two prospectors named T. Reid and W. Budd worked the area immediately to the south of the Boppy Mine, and there sank a shaft to a depth of about 40 feet. Gold was obtained in quartz stringers, both in the shaft and in various costeaning trenches.

In 1899 it was reported that Budd and Party had a promising claim on the same line of reef as the Mount Boppy. In the year 1901 the shaft had been sunk to a depth of 150 feet, but it was not known definitely that the lode worked was continuous with the Mount Boppy lode.

During the following year the mine was worked by the Boppy South Company. A payable reef was reported.

An attempt was made the following year to secure capital to work the lode.

Prospecting appears to have been done on this site during the following year, and on the leases held by W. Bakewell, adjoining the Mount Boppy Mine to the south, a diamond drill was being used, with the intention of finding the Mount Boppy lode extension.

> "A new company, with a nominal capital of £150,000, and a working capital of £60,000, of which £50,000 have been subscribed, has been formed in London, to work the southern leases of the Boppy Mine, together with what is known as Bakewell's leases and the leases of the Boppy South Gold-mining Company."*

Mr. J. Polkinghorne, in reporting† on the Cobar Field in 1907, stated that "the South Mount Boppy Company during the year sank two shafts, 'Nesham's,' 200 feet, and 'Hoffnung's,' 230 feet, and erected a winding plant on each."

Prospecting operations were vigorously carried out during 1908, both in Nesham's and Hoffnung's shafts. The former was carried down to a depth of 310 feet, and the latter to one of 300 feet. A Cornish lift was placed in Hoffnung's shaft. Small patches of gold stone, but nothing of a continuous nature, were found. Thirty men were employed during the year.

During 1909 twenty-three men were employed, and the Hoffnung shaft was sunk to a depth of 500 feet from the surface.

The accompanying extract has been taken from pp. 16 to 20 of the Directors' Report of the South Boppy Mine for 1910:—

> "During the period under review the original programme laid down at the inception of this company has been completed, namely, the driving of an east and west crosscut a distance of 500 feet in each direction at a depth of 500 feet in the Hoffnung shaft.

"The western crosscut was driven to locate the Mount Boppy main lode, which was expected to be cut about 80 feet west of the shaft. There was, however, no sign of a lode at that point, but about 200 feet from the shaft,

* Annual Report, 1903, p. 11. † Annual Report, 1907, p. 91.

SOUTH MOUNT BOPPY G.M.Co

PLAN OF WORKINGS

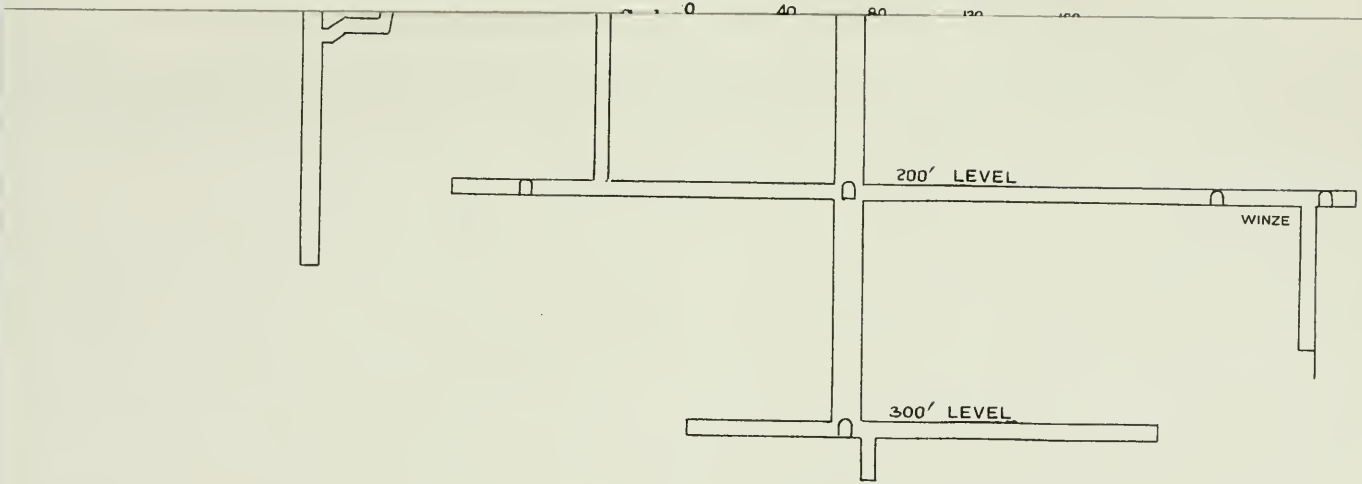


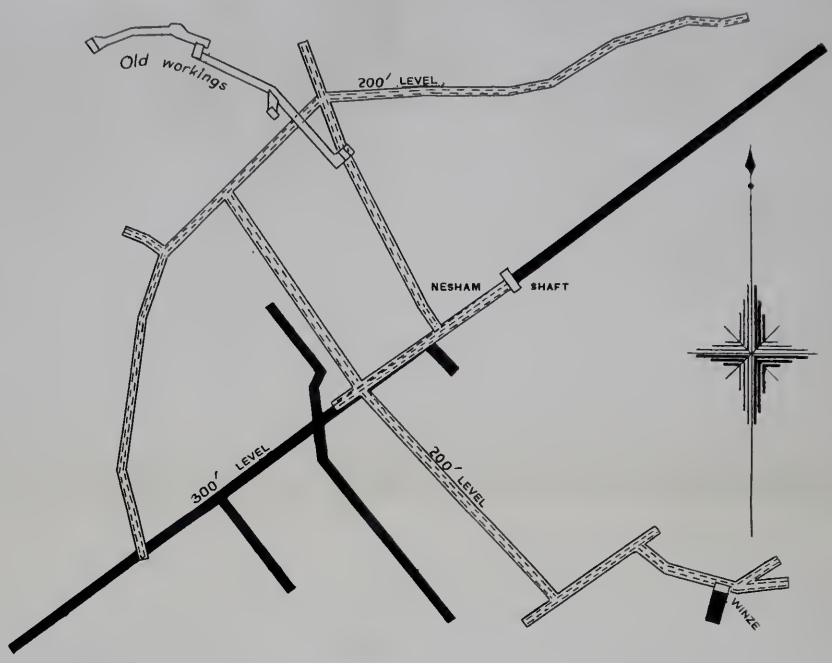
PHOTO-LITHOGRAPHED BY W. A. GULLICK, GOVERNMENT PRINTER, SYDNEY, N.S.W.

SOUTH MOUNT BOPPY G.M.Co

PLAN OF WORKINGS

Scale 0 40 80 120 160 Feet

Taken from Mine Manager's Plan.



LONGITUDINAL SECTION

NESHAM SHAFT

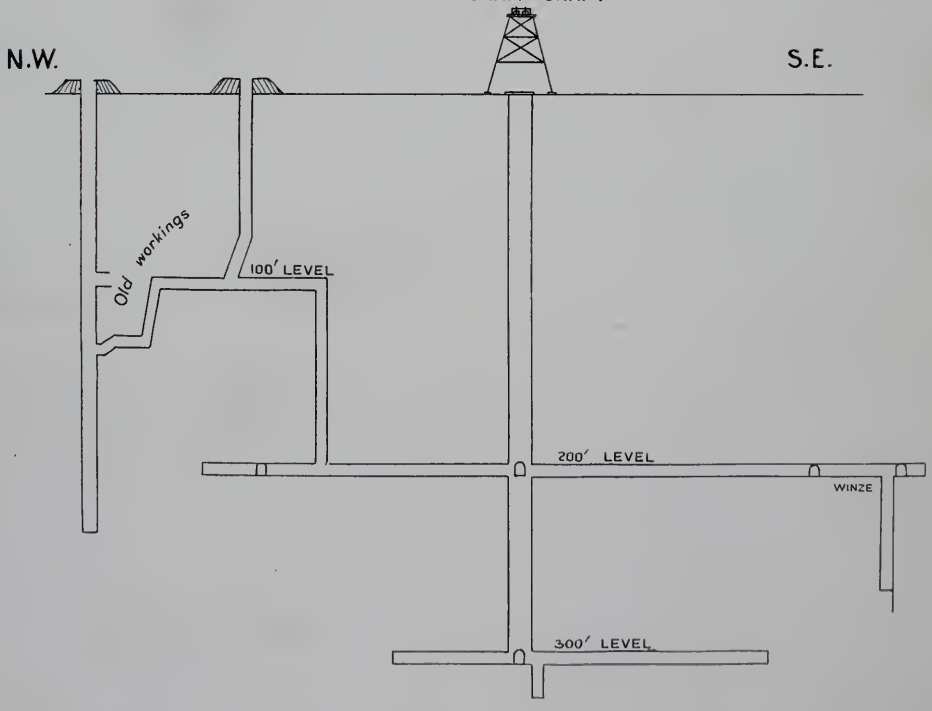


PHOTO-LITHOGRAPHED BY W. A. GULLICK, GOVERNMENT PRINTER, SYDNEY, N.S.W.

a channel about 30 feet wide, and having a well-defined wall, was struck. A fair stream of water was also encountered in this channel, which rendered the shaft comparatively dry. This formation was further exposed by a drive, but did not reveal any values. Another likely formation was intersected further west, and driven on, but proved to be valueless.

"The eastern crosscut was driven on to explore the unwrought ground in that direction. Nothing of a payable nature was struck, however, although two hopeful patches were intersected and driven on without producing any encouraging results.

"Apart from carrying on these operations, considerable attention has been devoted to developing the properties situated to the east of the Mount Boppy Mine, and known as the East Boppy, Birthday, Canbelego King, Reid, and Rankin, and Hidden Treasure. These properties were held under a twelve months' option by this company. The three first-named claims appeared to be the most promising, consequently it was on these that development was undertaken. This work has exceeded 1,400 feet in drives and crosscuts without encountering anything of a payable nature. From time to time promising-looking patches of stone were struck. In every instance, however, they were valueless. In view of this disappointing fact, and there not being any sign of improvement, it was decided at the end of September to cease work on all the claims.

"*Hoffnung Shaft.*

"*500-foot Level—Crosscut East.*—This crosscut has been driven 459½ feet during the period under review, making a total of 510 feet from the shaft. At first bands of hard limestone and slate were driven through. At a distance of 170 feet a change was first noticeable, the limestone decreasing in quantity, and a corresponding increase taking place in the slate, which became more mineralised, and contained veins of quartz. Water, also, in fair quantity, began to flow from the face. The quartz became more abundant, ultimately covering the whole face. This being the most promising patch met with since driving commenced, it was decided to further explore it by means of a drive north. This was started at a point 264 feet from the shaft, and was extended a distance of 24 feet from the crosscut. It was then stopped, owing to poor results being met with. A drive south in the same formation was then started. At first, appearances were more promising than in the drive north, the quartz being more abundant and more mineralised. As driving proceeded, however, the quartz diminished in quantity, ultimately disappearing. Driving operations were then suspended, the face being 19½ feet from the crosscut. Samples taken from both these drives only contained a trace of gold per ton.

"From 264 feet to 480 feet clean slate country was passed through, showing very little mineral or quartz. At 480 feet a promising patch of stone was intersected. It consisted of blue quartz, with small quantities of galena and blende present. For a distance of 26 feet the crosscut was in lode formation. At 506 feet a well-defined wall running north and south was struck. This was the eastern wall of the formation. The wall was driven on north and south a total distance of 45½ feet without encountering any values. Driving was consequently stopped, and the crosscut was restarted. It was driven 4 feet beyond the wall and discontinued, as the face being in clean slate there was nothing to warrant further exploration.

"*500-foot Level—Crosscut West.*—During the period under review this crosscut has been extended 457 feet, making a total distance of 507½ feet from the shaft. For the first 200 feet of driving bands of limestone and slate were encountered. A fair quantity of water was then struck, and a change occurred in the crosscut in the form of numerous patches and veins of quartz. Subsequent operations proved that a channel had been intersected, the width being about 30 feet, and having a well-defined eastern wall, but no defined west wall. The lode matter consisted of dark slate, with an abundance of highly mineralised quartz, with occasional small patches of galena and blende. The presence of this latter mineral was regarded as a particularly favourable feature, blende being one of the minerals most commonly associated with gold in this district. A low gold value of 1 dwt. 3 gr. was obtained from a sample taken near the western wall of the channel. Where this value occurred (246 feet from the shaft) a drive south was started. It was driven in a tough slate showing very little quartz or mineralisation, and of no value. After 28½ feet had been driven in this barren country further work was suspended. The north side of the crosscut was then stripped, but revealed nothing promising, consequently operations were discontinued in that direction.

"Since the appearance of water in this crosscut the shaft has been comparatively dry. This would lead one to draw the conclusion that the formation met with at a depth of 300 feet in sinking the shaft, and the formation met in this crosscut, are one and the same, seeing that it was at a depth of 300 feet that water was first struck, and now, at a depth of 500 feet, water is struck again, which has the effect of draining the upper part of the channel, and rendering it comparatively dry.

"Limestone and slate were all that were encountered in the crosscut west of the channel for a distance of about 100 feet. A well-defined vein about 3 feet wide of quartz and calcite was then intersected. Although without values, it was decided to further expose it by a drive south. The drive was extended a distance of 17½ feet. The quartz then split up into a few small stringers, and the walls, previously well defined, disappeared. Further driving was then stopped, and the crosscut continued. For a distance of 131 feet nothing but clean slate was met with. A band about 10 feet wide of conglomerate was then intersected, the conglomerate consisting of a mass of rounded fragments of quartz thickly embedded in slate, iron pyrites being distributed through the whole. Samples taken of this formation were devoid of any values. The crosscut was continued 6 feet beyond the formation, making a total of 507½ feet from the shaft. The face then being in clean country slate, and valueless, further driving was discontinued."

The accompanying instructive* note on this mine was written by Mr. J. B. Jaquet in 1905:—

> "*Mount Boppy South.*—This mine, as will be seen, is considerably to the east of the main line of reef, and about a mile distant from the last point where the reef can be seen upon its southern extension. The Mount Boppy reef could only pass through this mine in the event of it swinging round considerably to the east. Having regard to this fact and the steep pitch of the saddle, I think the reef which has been discovered here is much more likely to prove to be part of a parallel reef. The quartz forming the outcrop is certainly somewhat similar in

* Annual Report, 1905, p. 70.

character to that of the Mount Boppy reef, but neither galena nor blende has been met with below. A shaft has been sunk to a depth of 200 feet, and a considerable amount of other work done, and a strong reef, which, I am informed, is more or less auriferous throughout, opened up; but this is not of such a character as to enable me to express an opinion as to whether the main reef is a saddle or not. There are, however, to be seen in the mine certain arch-shaped bodies of quartz, which would seem to be small saddles."

The following notes made by Mr. G. H. Blakemore to the directors of this mine in 1903, are also interesting, in view of the fact that most of the prospecting shafts mentioned by Mr. Blakemore were inaccessible to the writer during the geological survey of Canbelego.

"The property consists of three blocks, namely, G.L. 7 of 6 acres (on which practically all the prospecting work has been done), and two (2) blocks of 10 acres each. . . . The northern edge of G.L. 7 is south-east of the last workings of the 'Mount Boppy Mine,' about 1,800 feet.

"*Workings.*—These consist of three shafts—one, the main shaft, is vertical and 152 feet deep; second is an air shaft about 25 feet deep connecting through a crosscut with the main shaft; and the third is a vertical shaft 50 feet deep. . . . There are, in addition, one or two costeans and trenches on the two veins of quartz that show.

"*The Main Shaft.*— . . . . Immediately where the crosscut leaves the shaft (30 feet from the surface) there is a body of quartz—the western vein, on which this shaft is sunk. It is about 4 ft. 6 in. wide at this point. . . . In the eastern end of this crosscut, where it connects with the bottom of the air shaft, the eastern vein of quartz is encountered."

The report then proceeds to deal with the class of ore and the faulting and crushing observed in the working, at the 110 and 152 foot levels, put out from the main shaft. Mr. Blakemore states his difficulty in classifying the patches of quartz found in the 110 and 150 foot levels. "I am inclined," he says, "to think it is the western lode." He mentions the frequent signs of disturbance in the shaft walls, and calls attention to the advisability of following the quartz.

"No. 2 shaft is situated 93 feet south-west of the main shaft. It is 50 feet deep, without timber or ladders. The sinking was carried out on the eastern vein in which quartz is continuous, appearing to be about 3 or 4 feet in average width.

"On the surface two distinct reefs are visible north of the main shaft. 'The western reef is ill-defined; its strike is about north-west, it outcrops for 67 feet, and a trench along it shows its width to be about 5 feet. . . . At a point 34 feet east from this vein, the easterly vein is slightly visible in loose rocks marking its course. Standing on the main shaft, and looking north, it is clear that between it and the crop of the two veins just mentioned, a fault has occurred which has heaved both the veins to the east. . . . South of the main shaft the two veins crop at intervals as far as the No. 2 shaft, from there on to the boundary of G.L. 7 and G.L. 4 they are covered with alluvial. In two costeans on the south boundary they are visible again.'

"*General.*— . . . . On the southern boundary of G.L. 9 there is a prospecting shaft sunk in quartz . . . 9 feet wide. This shaft proves a continuous lode on the Mount Boppy Gold-mining Company's property of 1,100 feet, and is strong evidence of the persistence of the lode. About 150 feet south of this shaft, on G.L. 8, the reef has been stripped again, but the trend of the reef is more westerly at this point than in any part of G.L. 9. So that, unless some very sharp turn, or a fault of some magnitude lies between the most southerly portion of the exposed reef on G.L. 8 and the north boundary of G.L. 7, big enough to twist or heave the Mount Boppy lode from its normal course, bodily, to the east for some 18 to 20 chains. . . there is a strong element of doubt about (*these*) reefs being the continuation of the lode worked in the Mount Boppy Gold-mining Company's G.L. 9. Between the last workings of this company, coming south, and the crop on G.L. 7—a distance of about 1,800 feet—there are no croppings visible. Whatever there may be of reefs is hidden by several feet of loam. . . . I prefer to believe that the reefs on G.L. 7 are parallel reefs. . . ."

A discussion of the possible extension of the Mount Boppy reef beyond the present workings may be found on pp. 78-81 of this report.

North Mount Boppy, Limited.

Situation.—Immediately to the north of the Mount Boppy leases, on the strike of the Boppy lode, parish Cohn, country Robinson.

Leases.—G.Ls. 39, 40, 25, 26, 45, 16, and 75 of 10 acres, 14 acres 0 roods 23 perches, 10 acres, 10 acres, 6 acres, 10 acres, and 10 acres respectively. Total, about 70 acres.

The earliest official mention of the mine appears to be contained in the Annual Report of the Department of Mines for 1902. "The same may be said of the Boppy North (Hardie and Party), and in this mine, as elsewhere round Mount Boppy, prospecting is proceeding vigorously." (p. 13.)

In the same official publication for 1905 another reference is made to the mine: "At the Boppy North Mine steady and consistent work characterised the year's operations. The main shaft has been sunk to the 200-foot level, and at that depth a crosscut was driven to intersect the lode. A level has also been driven 200 feet along the lode. A winding plant has been erected, and an air compressor to work the rock drills. As water has been met with, a pumping plant was to be installed." (p. 13.)

In the year 1906, an auriferous lode was opened up and driven on at the 50, 100, 200, and 350-feet levels, with promising prospects.

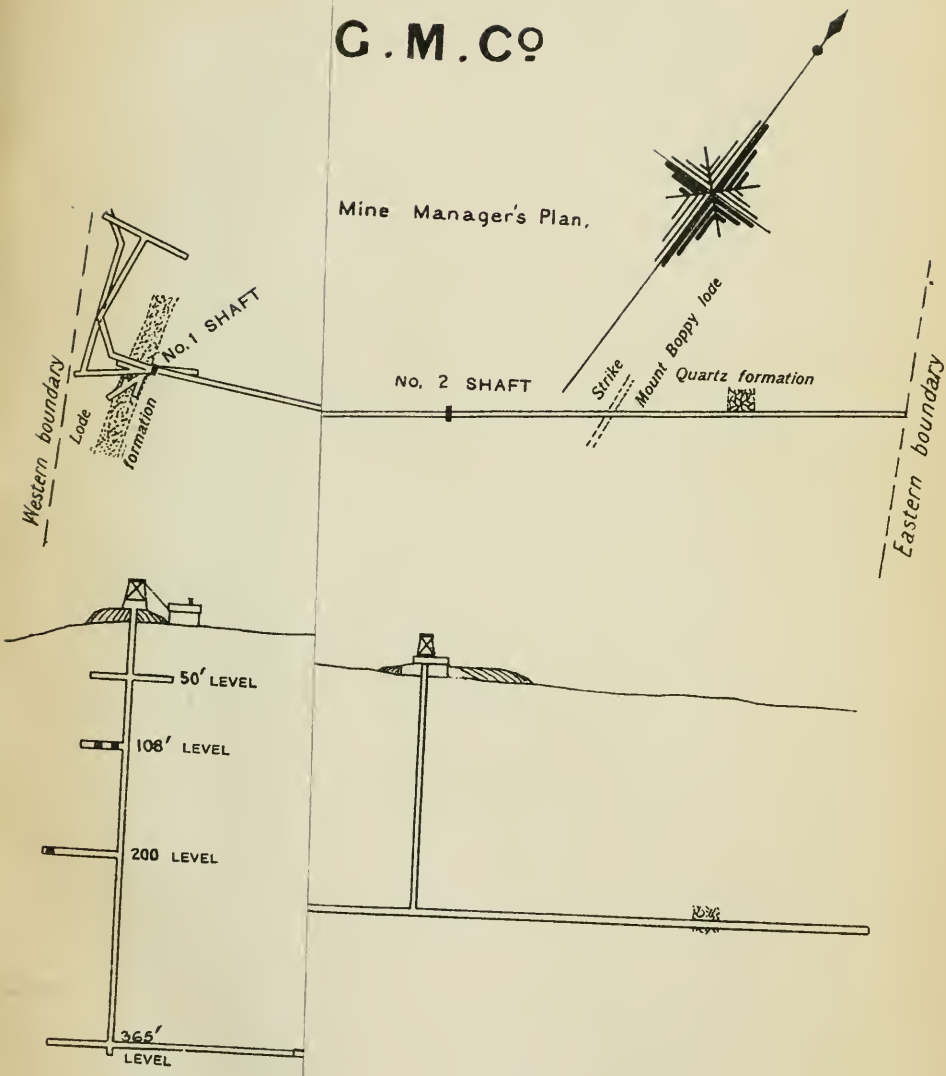
In 1907 the main shaft was carried down to a depth of 370 feet. The eastern crosscut was continued to a distance of 243 feet from the shaft, and "on the western lode the north level had been driven 150 feet."*

During the following year twelve men appear to have been constantly employed on the mine. The length of the crosscuts by this time had amounted to 750 feet.

The workings of the North Mount Boppy Mine not being accessible during the geological survey of the Canbelego field, and the official reports dealing with this mine not yielding detailed information as to prospecting operations, it has been considered advisable, in general mining interests, to make

* Annual Report, 1907, p. 13.

Shaft, Mount Boppy North Mine.

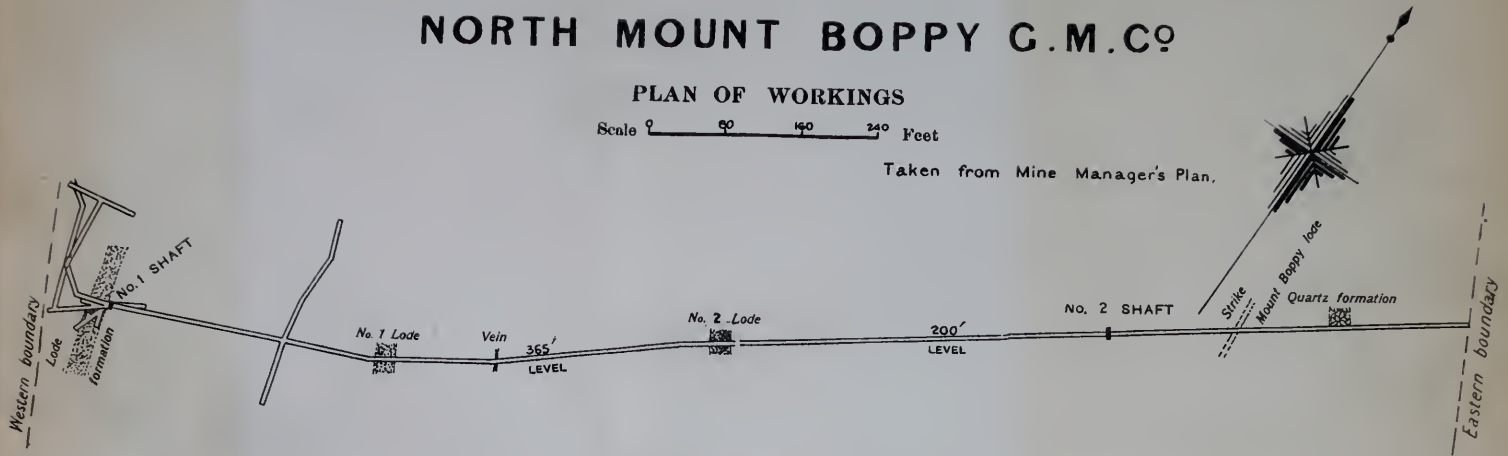

G.M.Co
Mine Manager's Plan.
No. 1 SHAFT
No. 2 SHAFT
Western boundary
Lode
formation
Strike
Mount Boppy lode
Quartz formation
Eastern boundary
50′ LEVEL
108′ LEVEL
200 LEVEL
365′
LEVEL

NORTH MOUNT BOPPY G.M.Co

PLAN OF WORKINGS

Scale 0 60 120 240 Feet

Taken from Mine Manager's Plan.



LONGITUDINAL SECTION

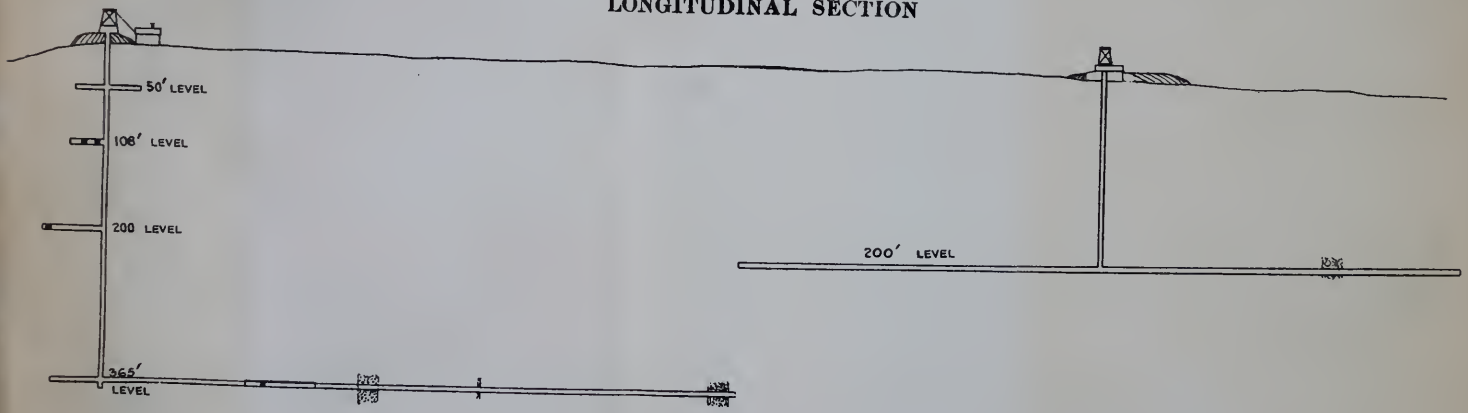


PHOTO-LITHOGRAPHED BY W.A. GULLICK, GOVT. PRINTER, N.S.W.

the present report as complete as possible by reproducing portions of the reports on this mine to the directors by Mr. J. Negus, General Manager of Mount Boppy Gold Mine, during the years 1909 and 1910.

"Renewed explorations were commenced during the month of March, 1909, with the object of locating the Mount Boppy reef in the leases held by this company.

"The work previously carried out was confined chiefly to Gold Lease No. 40. A shaft was sunk 365 feet near the western boundary and about 1,138 feet west of the general strike of Mount Boppy lode. From the bottom of the shaft a crosscut was extended in an easterly direction a distance of 688 feet. Operations then ceased.

"When it was decided to rework the property it was considered advisable to abandon the old workings and to sink a new shaft midway between the face of the eastern crosscut, extended during the former working of the mine, and the eastern boundary of Gold Lease No. 16.

"Gold Lease No. 26 was selected as a suitable position to commence the sinking operations.

"The shaft is situated at 1,782 feet north of Taylor shaft, and 1,272 feet north of the most northerly workings in the Mount Boppy Mine.

"From the shaft a crosscut east 386 feet and west 373 feet, making a total distance of 759 feet, would cover the whole of the leases from the eastern end of the crosscut in the old workings to the eastern boundary of the mine.

"The size of the mine shaft is 13 ft. x 4 ft. 6 in. within timbers. There are three compartments in this shaft. . . . The shaft was sunk a depth of 200 feet. . . . Two plats were cut at the bottom of the shaft, and crosscuts started to explore the ground west towards the face of the crosscut in the old workings and east to the eastern boundary. . . .

"In the eastern crosscut a fair amount of oxidised quartz was intersected, but nothing in the form of a lode ore body.

"At a point 234 feet from the shaft a formation carrying quartz—a portion having a promising appearance—was met. A drive north was started in this formation, but the quartz cut out after firing the first holes in this drive. The drive, however, was continued a distance of 38 ft. 6 in. in schist, but the work did not open up anything of value.

"At a distance of 338 feet a drive north was started in a promising-looking bunch of quartz. This drive was extended 9 feet and discontinued, the quartz having cut out.

"The crosscut was continued to 386 feet, the eastern boundary of Gold Lease No. 16. The country in the end consists of schistose rock, and is similar to the ground explored east of the shaft.

"The western crosscut was extended 380 feet, that distance being immediately over the old workings. This crosscut did not carry the same quantity of quartz as the explorations in the direction of the eastern boundary. At a distance of 365 feet, however, bunches of barren quartz were prominent on the south side, but these were irregular and ill-defined.

"These bunches and veins of quartz are numerous in the country rock in this district to the east and west of Mount Boppy lode, but these have no connection with an ore body.

"With the exception of a distance of 24 feet between the old shaft and the western boundary the whole of the leases comprised within the company's area have been traversed from east to west for a distance of 688 feet at a

depth of 365 feet, and 766 feet at a depth of 200 feet, making a total distance covered by crosscuts of 1,454 feet. The whole of this work failed to discover a lode or defined ore body. During driving operations the crosscuts were regularly sampled, but gold values were not revealed.

"The work accomplished proves beyond all doubt that the Mount Boppy lode does not extend north in these leases, also that no parallel lode exists within the area traversed by the crosscuts.

"At various points on the company's leases, and more so north of the old workings, numerous trenches and costeans have been cut with the object of proving what may at first appear to be lode formation outcropping at the surface. These proved to be irregular deposits of quartz which did not continue for more than 2 feet to 4 feet in depth and a short distance in length, and did not contain any values." (Report for 1910.)

"Reference was made in the Annual Report for the year 1909 to the completion of the exploration of the property from the eastern to the western boundaries. The plan of the underground working shows that, at the 365-feet level east of the old workings, a formation named No. 2 lode was intersected in the crosscut at a point 614 feet from the shaft. This lode is 21 feet in width, and the crosscut was advanced a distance of 7 feet beyond and east of the eastern side of the lode. At this point work ceased.

"From the eastern or new shaft in Gold Lease No. 26 the western crosscut at the 200-foot level was advanced a distance of 380 feet west to a point in a direct line and immediately over the 365-foot crosscut, but did not extend west to cover the ground in which this so-called [*formation.*—E.C.A.] would exist, assuming it to continue above the 365-foot level in a direct line.

"To determine this point, it was decided to resume operations. Driving was, therefore, recommenced in the month of May. From 380 feet, the point where work ceased during the previous year, the crosscut was advanced a distance of 62 feet, making a total of 442 feet from the shaft. The country driven through was a barren slate of a less promising nature than anything previously met with at this level, and the prospects of locating anything in the direction being remote, operations again ceased.

. . . . . .

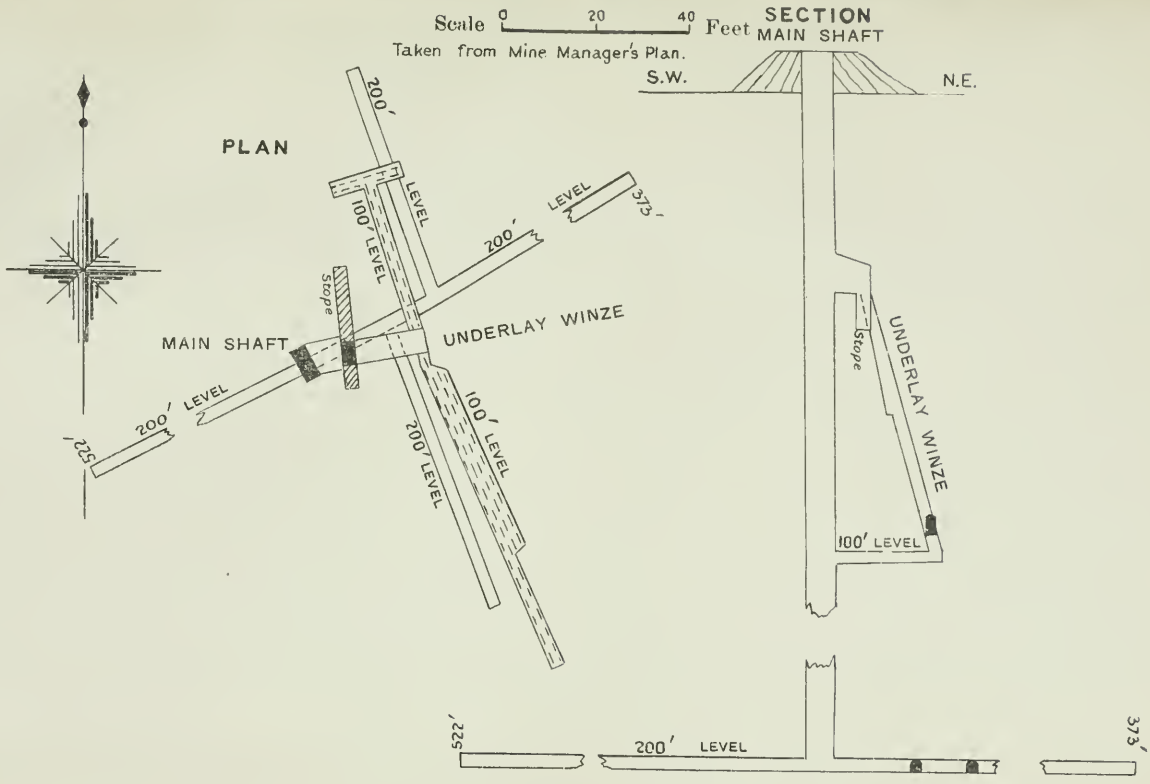
"In connection with this lode at the 365-foot level east, it is safe to assume that no values were obtained as no drives in either direction were extended, the formation being penetrated by the crosscut only. Therefore, it is evident the management at that time did not consider the discovery of sufficient importance to continue development operations." (Report for 1911, pp. 16-17.)

The plan and section accompanying this description illustrate the method of prospecting adopted in the leases of the North Mount Boppy Company.

East Mount Boppy.

G.L. 18, parishes Florida and Geweroo, counties Canbelego and Flinders. Country generally undulating, and composed of slates, phyllites, and schistose sandstones and quartzites. The lode was found and prospected by a Mr. Hogan near the township of Canbelego several years after the discovery of the Mount Boppy Mine. Fifty tons of ore were sent to Wellington for treatment, but the returns are unknown. Shortly afterwards the mine was worked by a small syndicate. The shaft under the new management was sunk to a depth of 200 feet, and 200 feet of crosscutting were carried out

EAST MOUNT BOPPY MINE



Contorted Slate. North Mount Boppy Mine.

at a depth of 200 feet. Somewhat later the South Mount Boppy Mining Company took an option over East Mount Boppy (Hogan's block). The accompanying extract has been taken from the Directors' Report of the South Boppy in 1910, pp. 21-22.

"Work on this property during the past twelve months has been confined to driving north and south at the 100-foot level to determine the extent of the ore body at that depth, and to driving two crosscuts at the 200-foot level to prove the ground to the east and west of the shaft.

"*100-foot Level—Drive South.*—This drive has been extended a total distance of 75 feet. The first 66 feet was in a most promising formation of flinty quartz, and bearing a marked resemblance to the Mount Boppy ore. It was, however, entirely devoid of any values. On the south the ore was cut off by a slide, and on the north it gradually pinched out, the total length from north to south being 66 feet. The drive was continued a further 9 feet beyond the southern extremity of the ore-body, and was in a very barren oxidised slate with occasional stringers of quartz. The end being poor it was discontinued.

"*100-foot Level—Drive North.*—This drive, which has been driven north of the northern extremity of the ore-body already referred to, has been advanced a total distance of 35 feet from the crosscut. The country consisted of red slate with small veins of valueless quartz running through it. There being no inducement to continue this drive further it was stopped and a crosscut east and west put in 7½ feet in each direction from the face of the drive. Nothing of value was revealed by these crosscuts. Seeing no additional information could be gained by further work at this level, operations were suspended, and the extension of the two crosscuts at the 200-foot level undertaken.

"*200-foot Level—Crosscut East.*—At the time of starting work by the present company, this crosscut was already in 84 feet from the shaft. It was extended a further 289 feet, making a total of 373 feet from the shaft. During the whole course of driving, this crosscut has been singularly devoid of any appreciable changes in the country rock, which consisted of a hard barren sandstone. During the last 70 feet of driving slate has been more prevalent, containing patches of white quartz, these patches at times being fairly large. There has been no indication of a formation, and samples taken in this crosscut in no instance assayed more than 13 gr. of gold per ton. The present face is in a blue crystalline schist, with very little quartz. This end being so unproductive, it was stopped.

"*200-foot Level—Crosscut West.*—This crosscut was started from the shaft by the present company, and has been extended a total length of 522 feet. For a distance of 50 feet the crosscut was in a soft red oxidised slate, a very promising patch of quartz rubble was then struck. The highest assay obtained, however, in spite of its appearance, only yielded 13 gr. Beyond this point soft red slate continued to be met. As driving proceeded the slate became softer, until, at about 258 feet from the shaft a large band about 80 feet wide of decomposed slate was intersected, this band resembling clay, and contained numerous dark patches of manganese dioxide, of which samples were taken, but proved to be valueless. This soft clayey material was gradually replaced by red oxidised slate, similar to that met with at the beginning of the crosscut. The occurrence of quartz patches was more frequent during the latter part of driving; they were, however, without value.

The present face is in a soft bluish slate, with little quartz showing. This crosscut having been driven so far without encountering anything of a payable nature, and there being no immediate prospect of doing so, was discontinued. Although no formation or values were met in this crosscut, yet at times the slate had quite an encouraging appearance, and gave the impression of being more likely to contain values than the eastern crosscut, which always possessed a more or less barren appearance."

Canbelego King.

G.Ls. 51, 61, 69, and 73, parish Cohn, county Robinson; and G.Ls. 67, 68, and 76, parishes Cohn and Florida.

Country rock consists of slates, phyllites, quartzites, and schistose sandstones. The mine is alongside the Canbelego township.

Mr. T. Reid states that J. Pascoe was the original prospector of the Canbelego King Mine. At the start the mine was worked by a small syndicate of Cobar and Canbelego residents. A shaft was put down to a depth of 40 feet about the same time that Hogan's Blocks (an adjoining property) were being prospected. Twenty tons of ore are reported to have yielded 30 oz. gold. A drive put out from the bottom of the 40-foot shaft in a southerly direction picked up a gold shoot. At a depth of 70 feet the stone became poor, and nothing of value appears to have been found at a greater depth in this shaft. Another shaft was then sunk 100 feet west of the original one. This was sunk to a depth of 100 feet. From the bottom of the same a crosscut was put out to the east for 70 feet, and about 30 feet from the shaft in this crosscut a drive was put in for a length of about 50 feet. A crosscut was also put in to the west from the shaft for a distance of about 100 feet. At a later period the South Mount Boppy Gold-mining Company secured control.

"From the Canbelego King Mine there was produced and sold during the year 50 tons of ore, containing 100 oz. of gold, valued at £400."*

The following extract is from the Directors' Report for 1910 on the South Mount Boppy Gold-mining Company, pp. 23, 24:—

> "The shaft on this property is sunk vertically to a depth of 100 feet. At that level two crosscuts are driven east and west. There is a rise in the eastern crosscut, which is connected with the workings at the 40 and 60 foot levels, and which were worked from an old shaft. It was from these old workings that the former syndicate were supposed to have obtained their gold values. The workings in the eastern crosscut, at the 100-foot level, would be immediately below this point. Sampling results, however, showed that no values existed at this depth. Consequently it was not thought advisable to further explore this part, but to extend the western crosscut to intersect the Hidden Treasure shaft. This formation, as well as could be ascertained from the limited surface indications visible, would be cut about 300 feet west of the Canbelego King shaft. The western crosscut, which was already in 106½ feet from the shaft, has been driven an additional 257½ feet, making a total of 364 feet from the shaft. Disappointing results were obtained. The portion of the distance the crosscut was driven was through bands of slate and sandstone, with occasional valueless quartz stringers.

* Annual Report, 1906, p. 95.

CANBELEGO KING MINE

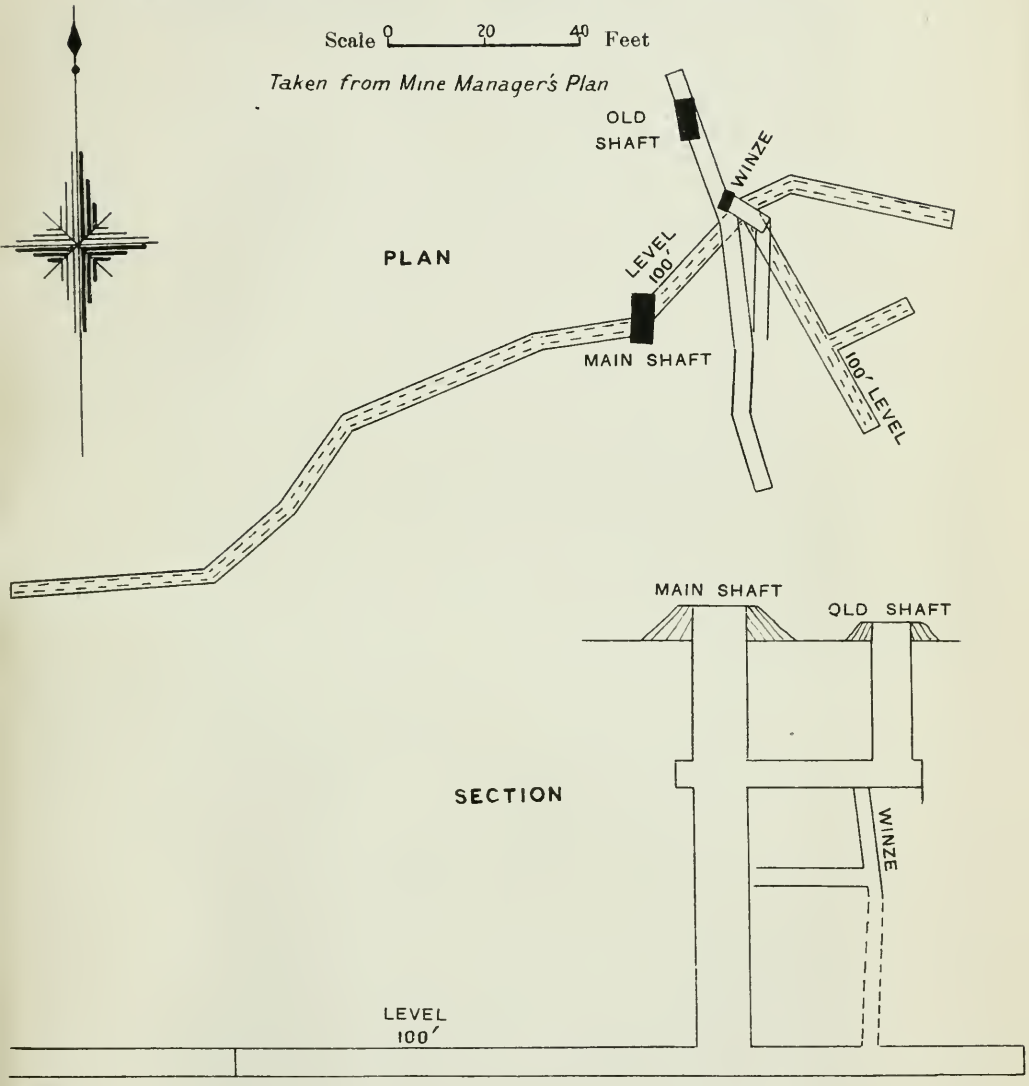


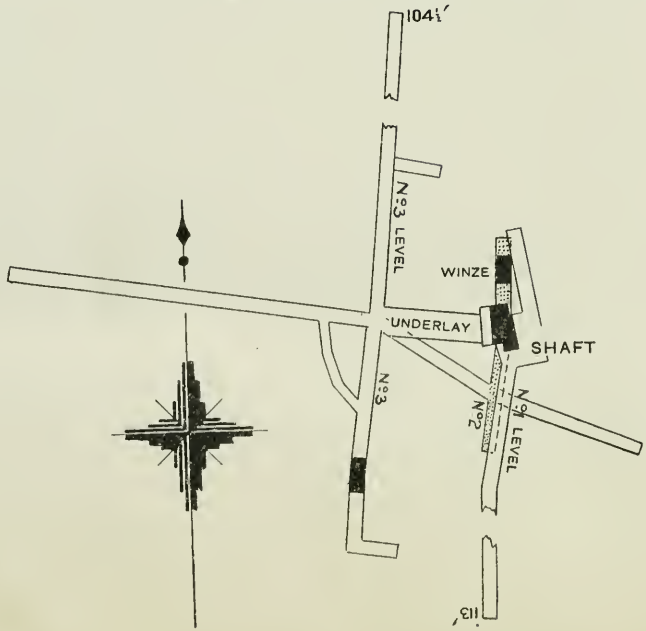
PHOTO-LITHOGRAPHED BY W. A. GULLICK, GOVERNMENT PRINTER, SYDNEY, N.S.W.

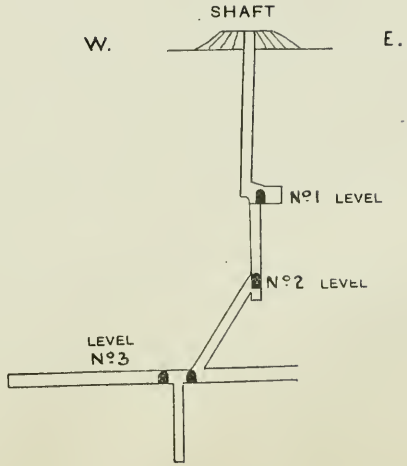
BIRTHDAY MINE

PLAN Taken from Mine Manager's Plan SECTION

Scale 0 20 40 Feet

Scale 0 40 80 Feet





"At 353 feet from the shaft a fairly well defined wall was intersected, and a change took place in the country for the succeeding few feet, the slate being in small quantities, while there was an abundance of quartz. The distance between the walls was about 6 feet. This reef coincides in strike and dip with the Hidden Treasure formation, the strike being north and south, and dipping steeply to the west. The highest result obtained from picked samples was only 13 gr. of gold per ton. In view of this disappointing value, the formation was not further opened up. The driving of the crosscut was continued a few feet beyond, and it was then stopped, owing to such poor results being met with, and the western boundary of the claim having been reached."

"During the latter part of the year this mine was reopened in one of the old shafts. A little prospecting in an easterly direction encouraged the prospectors to put a crosscut in east, where a strong body of stone was cut about 2 feet thick, which, up to the present, has yielded 27 tons of ore, valued at £189."*

The Birthday.

G.L. 13, parishes Cohn and Florida; and G.L. 16, parish Geweroo. Said to have been prospected originally by J. Pendergast. Surface prospects also reported to have yielded prospects up to 13 oz. gold per ton. A parcel of 70 tons sent away either to Dapto or Cobar is reported to have averaged 25 dwt. gold per ton.

During the prospecting campaign which followed immediately upon the discovery of payable ore in the Mount Boppy Mine, the Birthday was worked, and in 1906 the shaft had been sunk to a depth of 150 feet, and drives had also been put in at this depth. Work, however, was wholly in the nature of prospecting.

This mine subsequently came under the control of the Mount Boppy Gold-mining Company. In the absence of official reports on this mine, and owing to the fact that the mine workings are more or less inaccessible at the present time, it has been deemed advisable to quote extracts from the report made by the General Manager in 1910 to the Directors of the South Mount Boppy Gold-mining Company, Limited. In this way a record of the mine will be available to the public.

"*Seventy-foot Level—Drive South.*—This drive, on the western wall of the formation, which was already in 25 feet, has been driven an additional 88 feet, making a total of 113 feet from the shaft. The former face of this drive, which was in a hard quartzite, at the resampling assayed 3 dwt. 9 gr. For a length of 30 feet the quartzite remained regular, and, as far as appearances went, identical with that in the earlier part, and where the values were obtained. Notwithstanding that fact, no sample obtained in the latter part of driving assayed more than 13 gr. As the driving proceeded, the quartzite became very irregular, and at times entirely disappeared, its place being taken by schist and slate.

"Owing to this irregularity, it was determined to put in a crosscut east from face a short distance to ascertain whether more favourable indications existed in that direction. The crosscut was extended 13½ feet, revealing nothing but hard crystalline schist containing no values. It was subsequently stopped.

* T. S. Oldfield, Annual Report, 1913, p. 104.

"*158-foot Level—Drive North.*—Before work was undertaken this year the drive was in a distance of 34 feet, the end then being in a promising-looking state, which, although valueless, was sufficiently encouraging to warrant an extension of the drive. It was accordingly extended 70½ feet, making a total of 104½ feet from the shaft. The results obtained rapidly gave place to a barren schist, which continued to within 5 feet of the present face, the ground became harder, and valueless quartz made its appearance.

"*158-foot Level.—Crosscut East.*—This crosscut, which was already in 21 feet from the shaft, was continued a further 39½ feet to prove the ground hitherto unexplored, and lying to the east of the shaft. The first 12 feet was in a hard quartzite, somewhat gossany in appearance, with from time to time occasional promising-looking, but valueless, quartz stringers running through it. At about 30 feet from the shaft the quartzite became very close-grained, and possessed a flinty appearance. A sample taken at this point along the south side of the crosscut assayed 1 dwt. 3 gr. This value, however, was not maintained. The character of the country also underwent a change, the quartzite being replaced by poor-looking schist. Latterly the ground resembled in appearance that in the drive north, and is valueless."*

Other Canbelego Mines.

The Mount Boppy Copper Mine.

In presenting the description of this mine it has been considered advisable to include the report of the mine by Mr. J. E. Carne† as an introduction, and then to supply a few notes on the geology of the lode, together with the history of the mine since 1907.

"Mount Boppy Copper Mine (formerly New Burra Burra). Portions 50 and 51, parish Buppe, county Mouramba, 6 miles southerly from Boppy Mount Railway Station, and 4 from Canbelego. Discovered by W. Frost. Strike north-west in slate and sandstone close to junction of porphyry. Underlay slight to north-east. Lodestuff—slate, quartzite, and gossan. Ores—carbonates, black oxide, and yellow sulphide.

"Length of proving (in October, 1907) about 150 feet, depth 200 feet, gross output in recent campaign about 500 tons. 380 tons disposed of during 1907 for £1,800.

"History.—First lease taken up in 1886. At 13 feet carbonates and grey ore were struck in the lode, which had a thickness of 5 feet. Thirty tons of picked ore assayed 38½ per cent. of copper.

"In 1887 little work was done, the lease being sold to a Cobar syndicate.

"In 1888 mining was suspended, owing to scarcity of water; a tank, however, was being excavated, and a small reverberatory furnace erected.

"In 1889 a quantity of ore was reduced to matte, but the quantity was not stated.

"In 1890, 500 tons of ore were raised, and about 6 tons of copper produced.

"In 1891 stoping and smelting ceased, and Government aid was granted to further explore the lode.

"In 1893 the mine was closed.

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* Directors' Report, Dec. 1910, pp. 24-26.
† Copper-mining Industry, Mineral Resources, Dept. Mines, N.S. Wales, No. 6 (1908 Edition), pp. 248-250

"In 1897 Inspector D. Milne reported that the lode was being prospected; the main shaft had reached the 200-foot level, from which a crosscut 70 feet west exposed bunches of sulphides.

"In 1898 compulsory sale of surface gear put an end to operations.

"Further aid was granted for sinking in 1901 (P.B. 3986/01), and again in 1902 (P.B. 2026/02) for testing the east split of lode from 20 to 70 feet, and to crosscut 50 feet; resulting in discovery of a width of 15 feet of carbonate veins and strings of low grade. Aid granted to drive along this line for 50 feet.

"Reopened about 1904. Company formed to work it in November, 1906.

"Position in October, 1907:—Principal workings in M.L. 10. Two lodes —east and west—60 feet apart, striking north 60 degrees west. East lode vertical; west lode dips 12 degrees to 15 degrees to 90 feet, thence vertical. East lode, shaft and winze, sunk 259 feet, west lode 200 feet. Length of proving—east lode, 100 feet; west lode, 120 feet. Levels driven at 90 and 200 feet in both shafts, and crosscuts connecting both lodes at these levels.

"The sulphide zone of the *east lode* has been opened for about 100 feet. Lode about 3 feet wide; ore occurs in lenses of pure quality; rest of formation dredgy quartz and slate. Very little iron pyrites present. Winze 59 feet below 200-foot level filled with water; ore in it reported to be of good quality; a little still visible in roof above winze.

"Channel narrow at north end of level, evidently a blank. To south, channel filled with dredgy material; should be driven on.

"The *west lode* has been intersected by crosscut from the north end of 200-foot level in east lode. From this point north-westerly good ore was followed for some distance up to 10 feet in width. At 60 feet from the crosscut, however, it is narrow, but widens underfoot.

"To the south-east, beyond crosscut, the lens thins to about 1 foot of rich ore, and to a mere thread at 50 feet. A little ore is, however, showing on east wall. Channel being defined, should be driven on. A crosscut was driven north 30 degrees east for 50 feet to the porphyry contact which revealed no ore.

"Water making freely above 200-foot level; winze below was dry, but filled from upper levels.

"The ore raised from the large lens in west lode is of good grade. At surface it is broken, and hand-picked for 'firsts.' Fines from mining and spalling are screened. The screened ore is then concentrated in four small handjigs. These two classes are despatched for sale at Customs Smelting Works.

"The 'seconds' from hand-picking floors are stacked, probably aggregating several hundred tons.

"The following assays of carefully selected average samples of the different classes reveal their quality:—

No. of Assay.	Class of Ore.	Copper.	Iron.	Sulphur.	Silica.	Gold per ton.	Silver per ton.
		per cent.	per cent.	per cent.	per cent.		dwt. gr.
07-7438	Average of "firsts"	18·95	....	....	....	trace	8 17
07-7439	,, "seconds" (stacked) ..	1·50	....	....	....	....	trace
07-7437	,, "fines" from screens ..	8·55	14·42	7·94	49·00	....	5 10
07-7434	,, "concentrates" from jigs..	16·22	21·42	16·07	28·70	....	7 15
07-7436	,, "fines" from hutches ..	7·72	13·23	6·72	46·15	....	5 11
07-7435	,, refuse from jigs	2·70	10·08	2·74	59·25	....	3 6

"Close to the main Mount Boppy copper workings a shaft has been sunk in the north block in soft rotten slate without sign of ore. Southwards the lode outcrops through M.Ls. 50 and 51, and Mount Boppy South. In places gossany iron and ferruginous slate are prominent in the outcrop. Two shafts were sunk to 100 feet and 180 feet in M.L. 51. In the latter at 12 feet west in a crosscut about 20 feet of impregnated rock is reported to yield an average of about 2 per cent. of copper. A little carbonate and sulphide ore have been raised from it. A greenish pyritic slate on west wall doubtless accounts for the very ferruginous slate at surface.

"In the South Mount Boppy shaft adjoining, a 50-feet shaft on the west side reveals decidedly encouraging prospects, 3 to 4 per cent. carbonates being raised in some quantity, which could be picked to higher grade.

"From the data secured it appears that the Mount Boppy copper lode is formed of a series of lenses with blanks between. It is worthy of attention, but capital is necessary for necessary development, both vertically and horizontally, before establishment of local smelting works.

"The latest report, dated 12th March, 1908, records the depth of the winze at 70 feet below the 200-foot level. Driven 6 feet at bottom in solid yellow ore for full width of drive.

"The first payment under an option was made about the same date.

"During 1907, 380 tons of ore were disposed of for £1,800." (Annual Report, 1907, p. 51.)

The following notes are supplementary to those of Mr. Carne, and although partly the result of personal knowledge they are due mainly to information supplied by Mr. C. J. Elliott, inasmuch as the old Burra Mine, in which by far the greater amount of mining work has been done, was not accessible during the geological survey of the Canbelego field.

Mr. William Frost prospected the area under consideration about 30 years ago. A small company was formed in Cobar to work the lode discovered and a reverberatory furnace erected. This smelter was shut down at a later period and sold by auction. The property then appears to have passed under the control of Mr. W. J. Hogan. After the abandonment of the mine by this control Messrs. C. J. Elliott and J. Conley took up M.Ls. 10, 50, and 51 about the year 1904. M.L. 10 was worked in conjunction with M.L. 51 for twelve months. M.L. 10 (Old Burra) was then floated into a no-liability company of 50,000 shares at 10s. each, half paid up. Since that date the mine has been worked on and off until the close of the year 1912. The Old Burra was shut down about the 1st of November, 1912, and at this time ore was struck in M.L. 51 about 30 chains in a south-easterly direction. About the middle of 1912 Mr. C. J. Elliott took up an option over M.L. 51, and a no-liability company of 50 shares, at £20, was formed to work the mine. Owing to a find of good copper in a cross-cut at a depth of about 200 feet last December the shares of this company were in great demand for a short period, one share being reported as having been sold for about £200.

The lode worked in Block 51 has a promising gossan outcrop of considerable width near the junction of schistose slates and a belt of siliceous quartz-felspar porphyry. The mining workings show that the porphyry has a very high dip, but the evidence points to the conclusion that the porphyries are lava flows contemporaneous with the Silurian or Ballast sediments. The outcrop is not confined to either the porphyries or the schistose slates, but occurs both in the sediments and the lavas.

The lode is of great length, the outcrop being traceable clean through the width of M.L. 51 (40 chains), and thence south for a considerable distance into M.L. 1 to the south. North of M.L. 51 the outcrop is lost in M.L. 50, and the lode worked in M.L. 10 has not been proved to be continuous with that in M.L. 51.

Very little work has been carried out in M.L. 51. The width of the lode, as exposed in a crosscut from the shaft, appears to be about 12 feet. The shaft is vertical, 11 feet x 4 feet in the clear, with three compartments, and it is 200 feet deep. It has been sunk off the lode, the lode underlays west at about 1 in 8, and a crosscut about 100 feet in length connects shaft and lode. In the crosscut water appeared to be making. No ore was found in the roof of the crosscut, but half-way between the roof and the floor the gossans gave place to carbonates and black sulphides of copper mixed with solid limonite and country. Specks of yellow copper sulphides were scattered in slates and in lustrous sandstones. Forty-six tons of ore were obtained from the crosscut, and a shallow winze was sunk to the immediate north, below a short drive. From this 46 tons of ore were mined, which yielded 2¾ tons of copper.

Since December, 1912, work has been confined to sinking the shaft an additional 100 feet and cross-cutting the country to the lode.

Old Burra.—Lode near junction of quartz-felspar, porphyry and schistose slates, argillaceous and lustrous sandstones. Strike of lodge N. 55° W. and S. 50° E. of country W.N.W. and E.N.E. Dip of lode almost vertical towards west. Dip of country in open cut about 60° to S.S.W. Water level about 100 feet from surface. The outcrop forms a strong gossan, while the lode consists of quartz veins and stringers in altered slates, the quartz being frequently cherty in character, and at times in the form of lenses or eyes, whose longer axes are parallel, and whose shorter axes are collinear. The lode varies from 4 to 20 feet in width. The ore appears to have been introduced into the slates and porphyry by a process of partial replacement along a zone of weakness, The ore is very siliceous, and consists of yellow copper pyrites mixed with iron pyrites and quartz.

A sample secured from the 200-feet level was assayed, with the following result:—

976. Pyrites—

Gold	a trace.
Silver	10 dwt. 21 grs. per ton.
Copper	9·52 per cent.
Iron	47·74 ,,
Sulphur	16·60 ,,
Silica	4·25 ,,

Workings and Machinery.—Shaft 6 feet x 4 feet to a depth of 90 feet, thence 11 feet x 4 feet to a depth of 200 feet. Plat cut at 200-feet level, about 8 feet x 8 feet. Thence a drive put in northwards for 30 feet, with stringers of ore showing in face. A winze 90 feet deep was put down in this drive, which is stated to show good copper sulphides in the bottom. Thence a drive put in for 50 feet to the south-east, a little "dredgy" ore showing all through. This lode is known as the Eastern lode. Crosscutting was then carried out from the end of the south-east drive for a distance of 70 feet to the eastward. The so-called Western lode was intersected at this point. This western lode has proved the most productive of the veins or deposits in the property. A level from the

western crosscut at this point was put in to the north for about 100 feet, and to the south for a distance of 60 feet. The western lode varies in width from 2 to 10 feet. The bulk assay is reported to have been about 6 per cent. copper. All the ore has been stoped from the No. 2 to the No. 1 level.

Two winzes were sunk on this western lode about 100 feet apart. One winze was 30 feet, the other 20 feet deep. Good yellow ore is reported to be showing in the winzes.

A mill was put up five or six years ago, consisting of fifteen head of stampers, with one Wilfley and one Woodbury table. A Cornish boiler 26 feet long and 6 feet 6 inches high was in use. The concentrate from the mill were sold to Great Cobar.

During 1913 this mine produced 64 tons of ore, valued at £206. "This company registered during the year, and raised sufficient capital to sink the shaft a further 100 feet, and thence cross-cutting out to the lode. A suitable winding plant was installed, together with cage gear. . . . . It is the intention of this company to drive north and south on the trend of the lode, to endeavour to pick up the promising lode of No. 3 level."*

The Canbelego Copper.

The following notes on the earlier history of this mine have been taken from Mr. J. E. Carne's "Copper Mining Industry" :—†

"Canbelego Copper Mine (late Saunders').—M.Ls. 17, 18, and 36, parish Buppe, county Mouramba, 6 miles south of Canbelego, and about 7 miles from Boppy Mount railway station. Discovered by Mr. J. J. Saunders in August, 1901, who sank shafts 96 feet, 50 feet, 35 feet, and 38 feet deep, extending along lode for about 200 feet. Costeans expose a further distance of about 50 feet. Strike north-west vertical, in slate. Average width of outcrop about 35 feet, including bands of country carrying small veins and strings of ore.

"Position in October, 1907:—Deepest shaft, 250 feet, which cut ore at 90 feet; water level, 158 feet.

"Two faults slightly displace lode—at 78 feet to eastward, at 118 feet to south-east. Upper fault strikes N.W., and underlays S.W. at 45°; lower fault strikes N.E., and underlays N.W.

"At the 155-feet level the lode has been driven on for about 50 feet. In north drive and crosscut solid ferruginous ore exposed, containing considerable native copper. At 170 feet copper and iron pyrites occur in soft slate; signs of enrichment visible in the black powdery subsulphide coating, chalcopyrite.

"The gross weight of ore despatched by the discoverer totalled 63¼ tons, and returned an average of 28 per cent. of copper.

"About 17 tons of dressed ore at mine about 10 per cent. grade, seconds 2 to 3 per cent."

In 1909 development work was carried on, but owing to the great influx of water while sinking a winze work was temporarily discontinued. About 46 tons of ore were disposed of to the Great Cobar, Limited, from which 4½ tons of copper were obtained, valued at £274.

By the close of 1910 the main shaft had been sunk to a depth of 300 feet. 155 tons of ore were sold to Great Cobar, Limited, for a return of £1,132.

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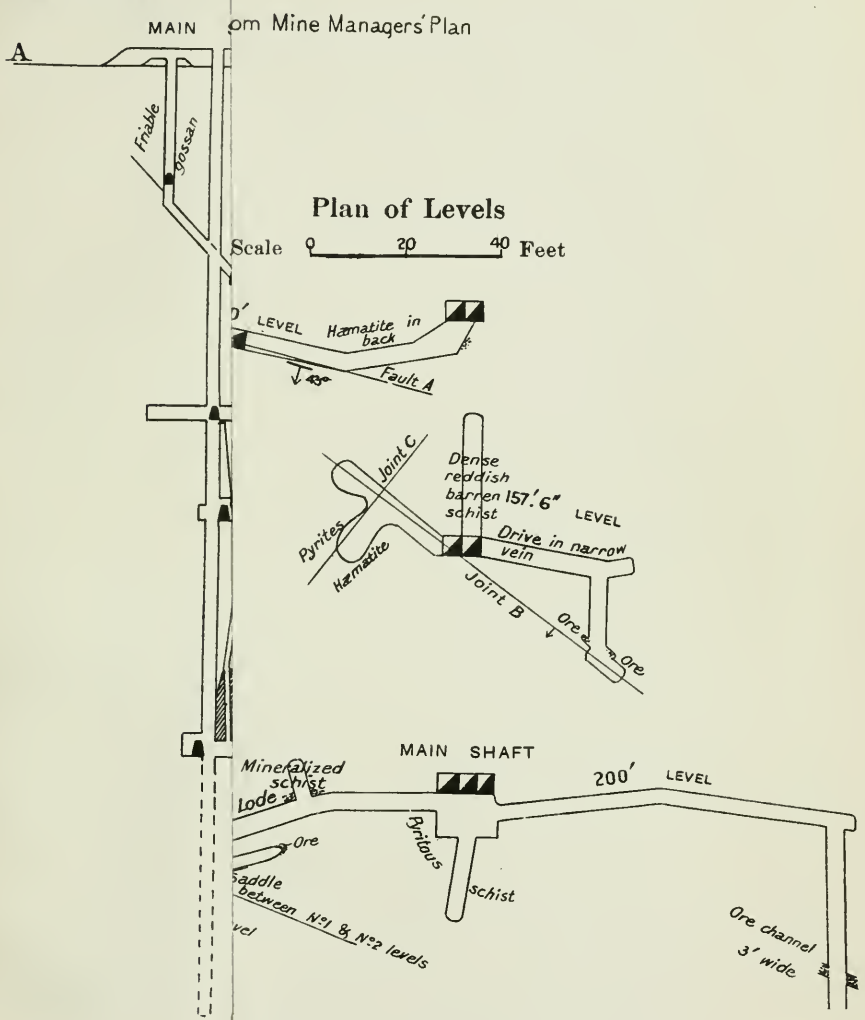
*T. S. Oldfield, Report for 1913 to Chief Inspector of Mines.
†Mineral Resources, Dept. Mines, N.S. Wales, No. 6 (1908 Edition), pp. 196,197.

NE

TRANSVERSE SEC



CANBELEGO COPPER MINE

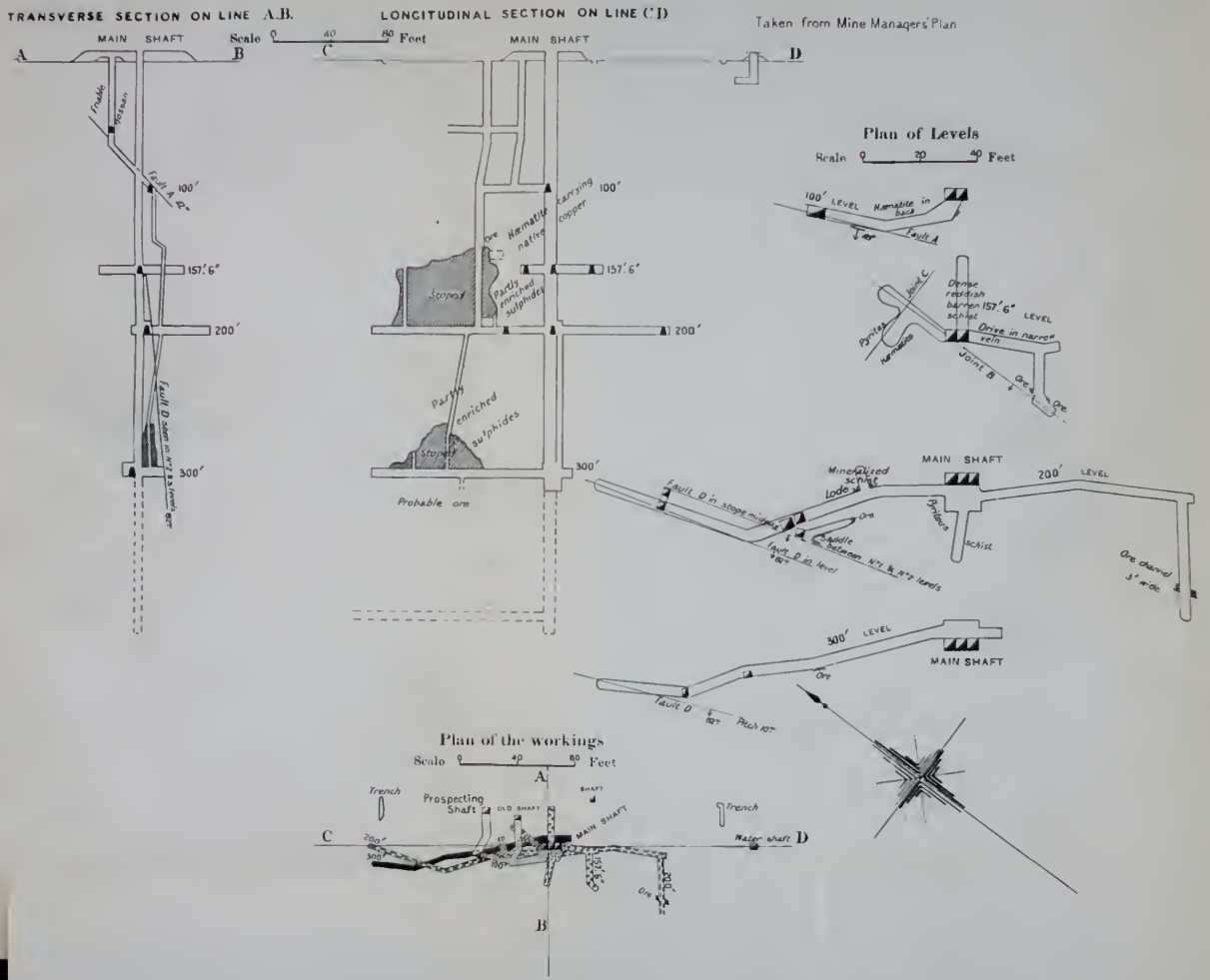


PHOTO-LITHOGRAPHED BY W. A. GULLICK, GOVERNMENT PRINTER, SYDNEY, N.S.W.

Very little work was carried out during the following year, but 141 tons of ore produced 17 tons of copper, the gross and net values being respectively £935 and £647.

The mine was not worked continuously during 1912.

"404 tons were raised, producing 32 tons of copper of a value of £2,018, which was despatched for treatment to the Great Cobar mines. Practically the whole of the ore produced was taken from the 300-feet level stopes north. The vein is small, but of fair grade, with good prospects."*

Geological Notes.—The country consists of sandstones and slates so highly altered as to present the appearance of silky slates, phyllites, and mica schists. In the latter the quartz occurs as small lenses, and the mica as small lustrous plates of brownish-grey colour. The sandstones and slates are at times much puckered.

The strike of the lode appears to be almost N.N.W. and S.S.E., and the underlay is negligible, the lode being practically vertical. Quartz occurs as thin stringers and as lenses along bedding and schist planes of country. Replacement of country by impure silica and by ore is common. A dyke, apparently of norite, parallels the lode a few chains to the east.

The lode is fairly wide in places, and two bands of quartz and pyritic stringers occur in a zone of crushing as much as from 20 to 40 feet wide in places.

Water level is about 155 feet from the surface, and the characteristic minerals below that level are copper and iron pyrites, quartz, and cherty material. The ore being won at the latter end of 1912 was of basic nature and well suited for smelting.

At the 150 and 135 feet levels grey ore (chalcocite), black oxide (?), and carbonates were worked.

Faults somewhat complicate mining operations. On the 300-feet level one occurs, dipping to the south at about 60 degrees. Another dips almost to N.W. at end of drive on 300-feet level, while a third occurs about 35 feet towards the shaft from the face, as seen during December, 1912. The latter is almost vertical.

Mining Development.—Three shafts have been sunk, one at a distance of 100 feet north of the main shaft, another 210 feet to the S.S.E. of the main shaft; both small and shallow. Main shaft is a vertical three-way shaft, 300 feet deep, 12 feet x 4 feet in clear below depth of 210 feet, 8 feet x 4 feet above 200-feet level. Levels put in from shaft at depths from surface of 90 feet, 150 feet, 200 feet, and 300 feet. Sump, 310 feet deep.

Drives.—At 90-feet level 20 feet long to north.

At 150-feet level, north drive put in about 15 feet, south drive 40 feet. At 200-feet level, north drive 137 feet, south drive 81 feet long respectively. At 300-feet level, north drive 140 and south 7 feet long respectively.

Crosscuts.—At 150-feet level western crosscut 30 to 35 feet long, eastern crosscut 40 feet long.

At 200-feet level a crosscut has been put out for 35 feet off south drive. One also runs straight from shaft to the south-west for about 50 feet. One also has been put in for 25 feet north of the shaft.

A winze has been sunk from the 200 to 300 feet level in the north drive immediately north of the "rise."

*T. S. Oldfield, Annual Report, 1912, p. 94.

The average height of the stoping to the north of the shaft at the 200-feet level is from 15 to 20 feet over a distance of from 50 to 70 feet. A "rise" said to be from 60 to 70 feet in height above the 200-feet level has been put in over the centre of the stoped ground.

At the 300-feet level a stope about 36 feet long, and from 15 to 20 feet in height, has been put in to the north of the shaft near the north end of the drive.

The accompanying plan and section of the mining workings have been prepared by Mr. A. Stuart Peters subsequently to the examination of the mine by the writer. Extra development work has been carried out, and Mr. Peters believes that the ore deposit will be found to occur in the stopes of the No. 3 level much in the same manner as it was found in the stopes above No. 2 level. In other words, he believes it follows a fault shown on the plan for some distance, and then passes into the crushed country to the eastward. Mr. Peters also states: "When on the slip, the ore is slickensided, and has a fair wall also on the east side, but where it leaves the slip the ore is wider and very erratic in its course, as well as having spurs and branches on both sides."

"This mine was worked continuously during the year [1913.—E.C.A.], raising 555 tons of ore, valued at £3,323."*

The Boppy Blocks.

G.L. 101, parish Cohn, county Robinson.—The shafts have been sunk in Devonian sandstones and tuffs to intercept the downward continuation of a formation which outcrops strongly as a wide belt of gossan a few yards to the east. A shaft was commenced by H. Smith and Company, and at a later date the shaft was carried down vertically to a depth of 200 feet, and crosscuts each 100 feet in length were put in east and west. The iron lode which the company sought was not found. At a shallow depth the Devonian rocks were passed through, and the underlying schists were penetrated, without commercial results. The ironstone outcrop appears to be due mainly to the gradual extraction and deposition of iron from the rocks at shallow depths. At a moderate depth below the surface it is highly probable that this gossan outcrop would pass into whitish, greyish, or yellowish sandstones.

Boppy Boulder.

M.L. 98, parish Cohn, county Robinson.—The shafts have been sunk in the sandstones, quartzites and claystones forming the rough southern end of Mount Boppy. The main shaft has been sunk with the intention of prospecting a wide and massive gossan outcrop. The workings were inaccessible below the 100-feet level during the visit of the writer in 1912, and the following notes on the prospecting operations have been supplied by Mr. T. Reid:—"This area was pegged out by Plunkett and party. A syndicate was formed, and a shaft sunk for 200 feet. At a depth of 100 feet crosscuts were put in 60 and 50 feet to west and east respectively. Forty feet from shaft in the western crosscut a drive was put in north for 50 feet. About 20 feet

* T. S. Oldfield, Report for 1.13, to the Chief Inspector of Mines.

in the drive north of crosscut a small patch of gold quartz was met with, which was said to assay 2 oz. of gold per ton. A winze was sunk about 20 feet on this stone, at which depth the gold values are reported to have ended."

"In the crosscut north-east from the shaft, and 30 feet from the shaft, a drive was put in about 50 feet to the south, and this showed a little gold all along the drive.

"At the 200-feet level a crosscut was put in for a distance of 70 feet to the west, and thence a drive was put out north from the crosscut. A crosscut was also put in to the east for a distance of 50 feet from the shaft. Other minor work was also done. The results were not encouraging, although surface prospects are reported to go from 4 to 13 oz. of gold per ton from the casing of the ironstone formation lying to the east of the shaft."

Mr. Inspector J. Polkinghorne reported on this mine in 1912 (P.B. 12-1,279), and stated therein that samples secured both by himself and Mr. Inspector G. Smith were low in gold values. In applying for aid from the Prospecting Vote, Mr. C. E. Wall stated that 250 feet of drives and crosscuts had been put in at the 200-feet level, and about 300 feet at the 100-feet level.

The whole of the visible portion of the large spoil-heap lying round the shaft consists of a light-grey quartzite. This represents the material won from the deepest workings, and is doubtless the downward prolongation of the steeply-inclined quartzite bed lying to the east. No trace of ironstone has been revealed by the deepest sinking. The strong ironstone mass lying east of the shaft thus appears to be wholly superficial, and to be the result of the gradual withdrawal of the iron from moderate depths by capillary attraction and the deposition of same at the surface under sub-arid conditions. The mine workings are wholly in the Devonian sediments, which here have been infolded with the surrounding schistose sediments of much greater age.

Boppy Broken Hill.

M.L. 22, parish Cohn, county Robinson.—The country is of slates, phyllites, schistose sandstones, and quartzite. Strong gossan outcrops occur to the south and east of the present shaft, especially to the south. The rocks of the country have been strongly compressed. The general strike of the sediments is N.N.W. and S.S.E., but in M.L. 23 the quartzites have a westerly strike and northerly dip. The beds are remarkably thin, and in places exhibit considerable similarity to the slates and sandstones of the Cobar Series. The shaft has been sunk 250 feet, and a crosscut has been put in thence for 40 feet. At a depth of 165 feet a crosscut has been put in for a distance of 40 feet. Aid from the Prospecting Vote has been granted for cross-cutting 70 feet in an opposite direction.

> "A small amount of cross-cutting was done at the 160-feet level to endeavour to pick up the lode outcropping on the surface. Prospects are considered only fair in this mine."*
>
> "About 100 feet of cross-cutting and driving was done on this site during the year, and except for 30 feet of driving on a small copper vein nothing else definite was met with."†

The metal sought is copper, but although the surface indications are promising nothing of value appears to have been found as yet.

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* T. S. Oldfield, Annual Report, 1912, p. 54. † T. S. Oldfield, Annual Report, 1913.

Reid and Ranken's Shaft.

G.L. 6, parish Cohn, county Robinson.—Country of contorted and schistose slates and sandstones of older Palæozoic age and overlying Devonian quartzites which have been compressed sharply between the schists. The shaft has been sunk in the Devonian sediments near their junction with the schists.

The area was prospected about 1896, a short time after the Mount Boppy discovery. A shaft was sunk for a depth of 170 feet, 90 feet on an underlay, the lower 80 feet being vertical. The underlay of the lode is to the west. At a depth of 100 feet a crosscut was put in to the west for a distance of 65 feet, and cross-cutting was carried out also for 30 feet in a south-easterly direction. At 170 feet depth a crosscut was put in about 60 feet in a southerly direction. A little gold was found all the way down during the sinking of the shaft. Departmental assays are reported to have yielded 3 dwt. gold per ton. The highest returns are said to have been half an ounce of gold per ton.

In common with all mines in the western portion of the State in sediments of definite Devonian age, this mine appears to have yielded poor results only.

The Shangoes.

North Shango Shaft, M.L. 63. Main Shango and related shafts, M.L. 64, parish Buppe, county Mouramba.

These properties were prospected about the year 1901 by a shaft named the Duke of Cornwall. This was sunk to a depth of 60 feet and cross-cuts put out thence for 50 feet east and west. Traces of copper were found, but no payable ore revealed. A Cobar company is reported to have worked the lode and to have treated 13 tons of material from the surface, but with unsatisfactory results. The lode appeared to pass into a number of stringers, and work was discontinued until the Shango Company commenced operations.

In 1907 the No. 1 shaft was 60 feet, and the No. 2 shaft, 90 feet deep. In that year Mr. J. Polkinghorne reported (P.B. 07-2,804) that the lode was rather tortuous in shape and that good samples of copper ore had been found near the surface. Aid from the Prospecting Vote was granted in 1907 and 1908, in 1907 to sink No. shaft from 90 to 150 feet depth, and in 1908 from 150 to 200 feet depth. (P.B. 07-2,804, 08-849.)

The country in which the Shangoes occur has been much altered. The characteristic rocks are silky slates and puckered sandstones, while at the southern portion of M.L. 64 a large outcrop of micaceous quartz rock or quartz schist forms a low ridge. A basic igneous rock has also been reported from this locality, but this the writer has not seen. The North Shango shaft is shallow, and has been sunk in silky slates and allied sediments near the boundary of M.L. 63. Quartz from the shaft forms "eyes" and lenses, and contains much chlorite and secondary mica. The main shafts have been sunk on M.L. 64 in silky, lustrous, and puckered slates, and in cross-bedded slaty sandstones. Both shafts are close together, and have been put down to test a lode which outcrops as a strong gossan.

REID'S MINE

Scale 0 20 40 Feet

Taken from Mine Manager's Plan.

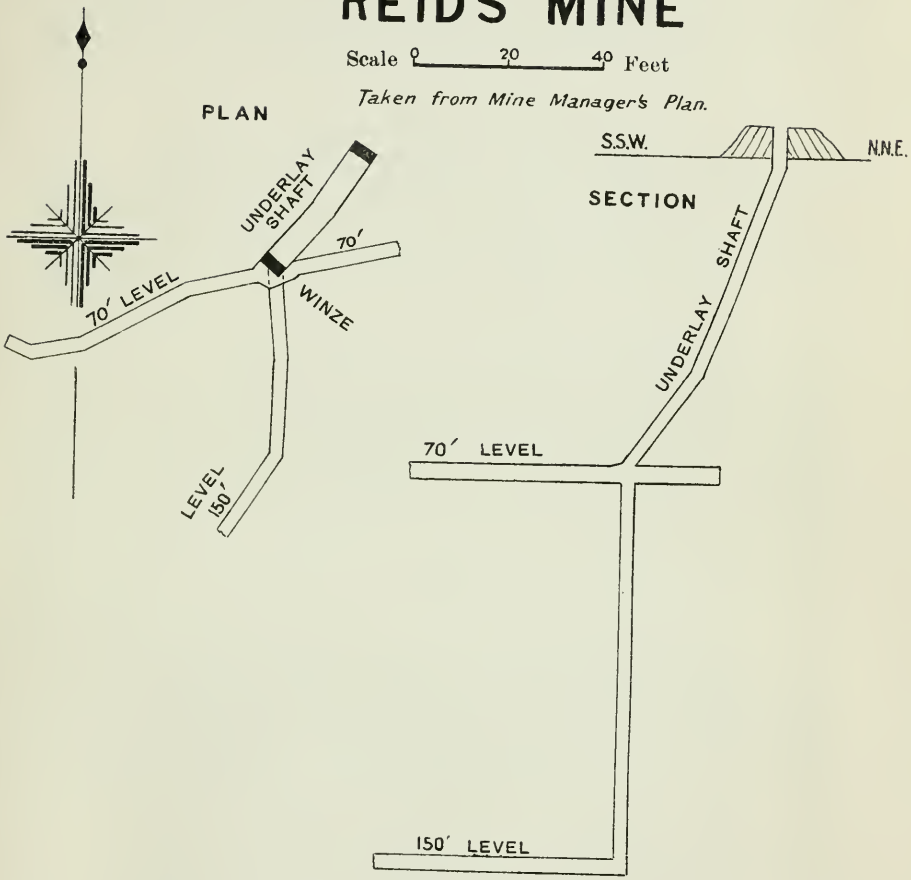

PHOTO-LITHOGRAPHED BY W. A. GULLICK, GOVERNMENT PRINTER, SYDNEY, N.S.W.

Towards the close of 1912 a start was made to test the lode afresh.

> "North Shango, at north-east corner M.L. 16, parish Buppe, county Mouramba, about 90 feet from course of lease. Prospecting, by shaft, for supposed continuation of Canbelego lode. Shaft in country; no ore."*

The Canbelego Peak.

M.L. 2, parish Buppe, county Mouramba. Mine on eastern fall of rough ridge or peak formed of older Palæozoic schistose sandstones overlain by powerful Devonian conglomerates, sandstones, and quartzites. The Devonian sediments here have a length of about 20 chains and a maximum width of about 3 or 4 chains. A great extent of quartz porphyry lies about 20 chains to the east.

The shaft has been sunk in the coarse, dense Devonian sediments. It is a curious fact that the miners spend much money in prospecting at points where the basal beds of this younger rock system outcrops. The explanation appears to lie in the fact that such basal beds frequently contain strong outcrops of gossan, which at times yield fair prospects for gold or copper. Nevertheless, in the writer's experience, lodes in rocks of definite Devonian age in the western district are of little value for mining purposes, being ill-defined and lacking in metalliferous contents at but moderate depths from the surface.

This claim is reported to have been pegged out by Mr. A. E. Moore. A Cobar company was formed to work the area. Nothing of value was found.

> "Shaft 174 feet deep, cross-cutting west [60 feet.—E.C.A.] to brecciated belt under peak. Country, quartz-pebble conglomerate and quartzite, with bands of ferruginous slate. Shaft sunk in latter, which shows faint traces of copper carbonate in cleavage. A little gold is reported in the breccia on surface about 70 feet west. If not payable in oxidised condition, unlikely to be in pyritic."†

The Mouramba.

M.L. 3, parish Buppe, county Mouramba.—Country of mallee-covered ridges of slates and schistose sandstones, and Devonian quartzites, sandstones, and conglomerates, which have been caught up between the enclosing schists by compression. The shaft has been sunk at the western margin of the Devonian sediments, and the evident intention has been to prospect them. Messrs. Reid, Ranken, and Smith were the original prospectors, and a company was formed at a later period in Sydney to work the property. A whip shaft (8 feet x 4 feet) was sunk vertically for 200 feet. A crosscut was put out thence for about 40 feet to the west, while about 160 feet of cross-cutting east and driving thence north was carried out. The mining workings here (as in most of the minor claims described in this report) were not accessible for inspection, but the whole of the large spoil heap appeared to consist of Devonian conglomerates, sandstones, and tuffs. The outcrop from the Silver-Lead Shaft lying about 25 chains to the north-west extends to within less than 100 feet east of the Mouramba shaft.

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* J. E. Carne, "Copper-mining Industry," 1908, p. 197. † *Ibid.*, p. 198.

The Mount Buppe Shaft.

M.Ls. 53 and 54, parish Buppe, county Mouramba, between 4 and 5 miles south of the Mount Boppy Gold Mine, and lying about 1½ miles to the north-east of the Canbelego Copper Mine. Country of slates and schistose sandstones, forming low ridges covered with whipstick mallee growths. Much quartz as reefs and segregations in locality. Strike of lode, N.W. and S.E.

> "Dip (of lode) S.W. at 43° . . . . . Outcrop consists of rubbly quartz and slate, with traces only of copper carbonates. Traces of gold only obtainable. Shaft in soft slate at 150 feet on hanging-wall side. Traces of carbonates in siliceous material on footwall."*

The Buppe Mine is said to have been found by J. Roach. In 1906 (P.B. 06-3,438) aid was granted to James Yeo and party to sink a shaft from 30 feet to 200 feet depth. At this time a second shaft existed, 17 feet in depth. In the following year the control of the mine passed from Yeo and party to a Cobar company known as the Buppe Copper Mining Company, No Liability, said to have been formed with 1,150 shares of £10 each.

At the stage when the No. 2 shaft had been sunk to a depth of 172 feet (72 feet vertical, and 100 feet on the underlay), the company was granted aid to sink the shaft another 100 feet on the underlay (P.B. 07-3,817). The shaft, however, appears to have been sunk only to a depth of 200 feet from the surface. Cross-cutting to the extent of about 50 feet in a westerly direction was carried out. A little copper was obtained. Mining operations were discontinued on the great fall in copper values during 1908.

Ranken's Reward.

M.L. 61, parish Buppe, county Mouramba. Occurs in the same mallee-covered patch of slates and schistose rocks as the Mount Buppe Mine, about 20 chains away in an E.N.E. direction. A very large, but apparently barren, quartz reef, possessing a strike of about N.W. and S.E., lies between the two mines.

The Ranken's Reward was found by J. Ranken, and then worked by a small company of Cobar and Canbelego residents. A shaft was sunk to a depth of 100 feet; thence a drive was put in to the south for a distance of 50 feet, and a crosscut in a westerly direction for 15 feet. Copper prospects from the surface are reported to have yielded as much as 13 per cent. copper. No encouraging results were obtained during sinking.

The underlay of the Ranken's Reward is to the east, while that of the neighbouring Mount Buppe is to the west.

The Silver-Lead.

M.L. 27, parish Buppe, county Mouramba. Country of schistose slates and puckered sandstones of older Palæozoic age, apparently traversed by a dyke of quartz porphyry. The latter, however, may represent only an outlier of a lava flow. The lode outcrops as an ironstone formation, with a general strike of N.W. and S.E., and containing carbonate of lead. The lode is small, and apparently has a slight underlay to the west. It is composed of small quartz veins and altered country containing silver-lead ore. It was prospected by J. Pender, and then worked by a local company.

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* J. E. Carne, "Copper-mining Industry," 1908, p. 106.

A shaft has been sunk vertically to a depth of 165 feet. At a depth of 125 feet a drive has been put in in a direction S. 55° E. from the shaft. This drive was about 50 feet in length at the close of 1912, and was being continued by T. Reid.

Nothing of value appears to have been found up till the present.

The Priests' (Mount Lockman or Bergin's Shaft).

"Bergin's Gold Lease (the Priests'), G.L. 1, parish Buppe, county Mouramba. Quartz and slate, with faint traces of copper carbonates in joints in crosscut on east side for a reported width of 20 feet. In west crosscut thin streaks of iron pyrites for 7 feet wide. This shows on surface as very ferruginous slate, with thin honeycombed bands after pyrites. Quartz abundant; reported to assay at best about 1 dwt. 3 gr. per ton. Joints glazed with thin films of black iron oxide, imparting a metalliferous look to outcrop. Shaft down 115 feet, and crosscut 55 feet at 100-feet level."*

In 1910 (P.B. 10-2,075) aid was granted from the Prospecting Vote to extend the western crosscut a farther distance of 80 feet, and to drive south from the 200-feet level for a distance of 50 feet.

The writer has been informed by prospectors that the shaft is 200 feet deep, that at a depth of 100 feet crosscuts have been put out east and west for distances of 30 and 25 feet respectively, and that at a depth of 200 feet a crosscut had been put out west for 60 feet, and a level had been driven for 50 feet to the south.

At 90 feet in the shaft the prospectors report having met lode material underlying west. This formation was passed through for 40 feet. Copper sulphate occurs on the walls.

The shaft has been sunk in a low ridge of very rough surface composed of green and grey sandstones, quartzites, together with sandy and silky schists. The general dip of the rocks is high, and to the west. Two outcrops of siliceous gossan lie a few yards east and west of the shaft respectively.

Nothing of value appears to have been found on this property up to the present.

Wealth of Nations.

Portion G.L. 22, 10 acres, parish Geweroo, county Flinders.—The lode is distant about 1 mile S.E. from Canbelego. It was found by P. Healy, and then worked by a local company. The lode is almost vertical, but with slight underlay to the west. The country is of slate, phyllites, and schistose sandstones.

The following notes have been obtained from P.B. 13-1514 papers:—One shaft is 125 feet in depth, with a drive in a south-west direction along a slide; another shaft lies 100 feet to south of this, and is 50 feet deep.

Aid was granted to drive 30 feet on the lode at a depth of 80 feet in the deeper shaft.

The lode is well defined, yielding prospects of free gold. Country disturbed. Lode only proved over short distance.

---

* J. E. Carne, "Copper-mining Industry," 1908, p. 197.

The Newhaven.

G.L. 2, parish Florida, county Canbelego. Country of slates and schists near their junction with quartz porphyry. The lode is said to be 4 feet wide within a zone of crushing. The strike of the lode is N. 10° to 15° W.

About the same time as the Mount Boppy lode was found, a Mr. Prendergast prospected the subject mine. At a later date a Cobar company secured control. A shaft 60 feet deep was sunk on a small vein yielding rich returns. A drive was put in 50 feet to the west from the bottom of the shaft. About 18 feet from the surface the commercial ore appeared to disappear.

Canbelego West Mine.

"M.L. 21, parish Buppe, county Mouramba. Prospecting shaft 135 feet deep, crosscut south-westerly for 30 feet at 116 feet. A trace of copper only. Country, slate and schist, with quartz strings. Copper stains very slight in costeans further west. No indication of defined ore body."*

Canbelego Queen.

M.Ls. 37, 59, parish Buppe, county Canbelego.—Country of silky and lustrous slates and schistose sandstones.

"Adjoining Canbelego North, on the north-west . . . . . Three shafts 30 feet deep on M.L. 37. A few stains of copper carbonate in quartzite and slate. Cut out at 15 feet."†

Canbelego North.

"M.Ls. 34, 35, parish Buppe, county Mouramba, adjoining Canbelego Mine on north. Prospecting for continuation of Canbelego lode. No ore; slate country. Shaft 80 feet."‡

Baker's Claim ("The Snakes").

Baker's prospecting claim, about 1 mile S.E. of Canbelego.—The country is of slate and schistose sandstone, forming low but rough ridges covered with mallee growths. Area prospected by three small shafts. One shaft 60 feet deep, but now idle; other shafts 40 feet deep. Worked in benches. A little gold won from the stone; latter patchy.

Hidden Treasure.

In main township of Canbelego. The country is of slate, schist, and puckered sandstone. A shaft was sunk about 50 feet deep, but the values of the contents obtained were negligible. The shaft is only interesting from the part which it played in the early history of the field.

Jack Lock's Shaft.

Prospecting area, parish Cohn, county Robinson, about 2 miles northwest from the Mount Boppy Gold Mine.

The country is of slates, schists, and sandstone, much contorted.

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* J. E. Carne, "Copper-mining Industry," 1908, p. 197. † *Ibid.*, p. 197. ‡ *Ibid.*, p. 197.

Aid was granted from the Prospecting Vote in 1904 to continue a shaft 15 feet deep a farther depth of 50 feet (P.B. 04-4,072.)

> "The vein is a well-defined one, and was but recently discovered. It is regarded as likely to be a continuance of the lode in the Boppy Mine."*

In November, 1904, Mr. Inspector J. Polkinghorne recommended the expenditure of aid from the Prospecting Vote to sink the shaft from 62 to 102 feet deep (P.B. 04-3,908).

The following year (P.B. 05-1,212) aid was granted to put in a crosscut for 100 feet west from the bottom of the shaft.

In February, 1906 (P.B. 06-644) the prospectors John Lock and Charles Shavington made an application for aid to continue the shaft from the 116 to the 216-feet level. "The shaft lode at its present depth gave us by private assay 6 dwt. 12 gr. gold per ton. Size of lode, from 9 to 10 feet. Character of lode, quartz leaders, slate, quartzite, and iron, all heavily charged with mineral."

Restdown Copper Mine.

Situation.—Fifteen miles south of Canbelego, at the junction of quartz-porphyry and Silurian (?) sediments, parish Bulga, county Flinders. The porphyry forms a low hill about 40 acres in extent, and on its eastern side it is traversed by a long and broad gossan outcrop. At a depth, this gossan passed into iron pyrites. To the immediate north a dyke of hornblendic rock outcrops which is almost indistinguishable, in hand specimens, from the basic igneous types found south of the Boppy Broken Hill shaft, and alongside the Canbelego Copper Mine. These occurrences suggest a possible relationship between the ore entries and the basic rocks.

The Restdown shaft is said to have been put down about the time of the C.S.A. boom in the Cobar district. It was "sunk under Government aid. Shaft 226 feet, in puggy kaolin, at junction of sedimentary rock, and intrusive quartz-felsite.

"In places along contact, kaolin converted into porcellanite is conspicuous, and sandstone into quartzite, arising from hydrothermal action following the intrusion. On surface, superficial iron oxide occurs fairly solid, but siliceous in places.

"Shaft sunk 133 feet vertical, then on underlay to 226-feet level. Driven from this point 40 feet east in soft puggy clay, all picking ground. Pug ferruginous and manganiferous, with occasional kernels of crumbly silica and quartzite. No copper ores visible, but assays said to reveal its presence in small quantity—less than ½ per cent.

"At a later date a sample from west crosscut in 23 feet forwarded by the manager, showing copper sulphides partially enriched by subsulphide, yielded on assay—†

"No. 07-7698—

Copper	3·02 per cent.
Gold	a trace per ton.
Silver	13 dwt. 1 gr. per ton."

* Inspector H. Hooke (P.B./04-2298).
† J. E. Carne, "Copper-mining Industry," 1908, p. 196.

The Budgery Mine.

M.Ls. 1, 2, and 9, parish Hermitage, county Canbelego. Towards the end of 1905 leases were taken up on the Budgery holding to mine for copper. The finding of the rich secondary ore of the C.S.A. near Cobar gave the stimulus to prospecting which led to the finding of the Budgery lode.

Mr. Inspector Polkinghorne,* in 1906, reported that while many of the prospecting parties had secured encouraging returns, nevertheless the Budgery was the only one which became a producer in 1906. In September of that year a mining boom was created in the locality by the finding of a patch of rich ore in the mine under consideration. Hundreds of acres were soon taken up under mining lease, and several companies were formed to work the newly-found deposits.

The main shaft of the Budgery was sunk 218 feet in 1906, and a crosscut was put in east-by-south for about 55 feet, when the ore body was struck; the crosscut was continued about 100 feet in an easterly direction, or, roughly, 15 degrees north of east in a lode body all the way. In 1909 very little work was done at the Budgery. From 20 tons of ore about 2 tons of copper were extracted. At the end of the year the shaft was 410 feet deep, and at a depth of 400 feet a crosscut was extended to the south-east.

In 1910, 3,210 tons of ore were raised and sold to the Great Cobar, Limited; 196 tons of copper were won, the gross value being £10,920. Nothing of value was discovered below the 400-feet level.

During the following year, 3,833 tons of crude ore were raised, of which 2,732 tons were sold to Great Cobar, Limited, for a return of 240 tons of copper, valued at £11,424.

Very little prospecting work was carried out during 1912. Of better class ore, 4,386 tons were raised for a return of £5,594, and sold to Great Cobar, Limited. Most of this ore appears to have been of a secondary nature.

The following notes on the Budgery Mine have been extracted from a report by Mr. J. E. Carne in 1908:—†

> "Discovered in 1906 by R. A. Sorensen whilst further prospecting a site previously tested for gold. . . . . .
>
> "The Budgery lode consists of a large impregnated mass of magnesian slates much crushed and jointed, with frequent slippy 'heads' or 'slides.'
>
> "Loose friable gossan extends down to a considerable depth, but is abruptly divided from the 'black' ore (subsulphide of copper) by a smooth, flat heading. The frequency of these headings striking and dipping in all directions evidences the results of some disturbing influence at no great distance.
>
> "In the closely-adjoining South Budgery, and probably in Budgery itself, a fine crushed quartz-felsite (?) occurs. The magnesian slates, moreover, are highly contorted on a small scale, and probably also on a large.
>
> "Copper ores, notwithstanding extensive prospecting all round the proprietary boundary, have not been proved outside of the original discovery, except a few carbonate stains in the Budgery Reward North.
>
> "The enriched black ore, or partially altered sulphides, was of good quality, but, as expected, proved to be superficial, the grade depreciat-

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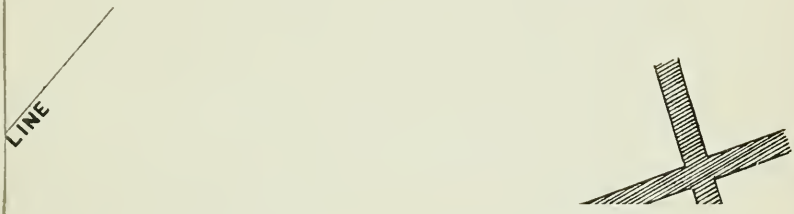
* Annual Report, 1906, pp. 94, 95.
† "Copper-mining Industry," 1908, pp. 194, 195.


LINE

BUDGERY MINE

PLAN OF WORKINGS

SCALE 0 20 40 60 80 FEET

Taken from Mine Managers' Plan.

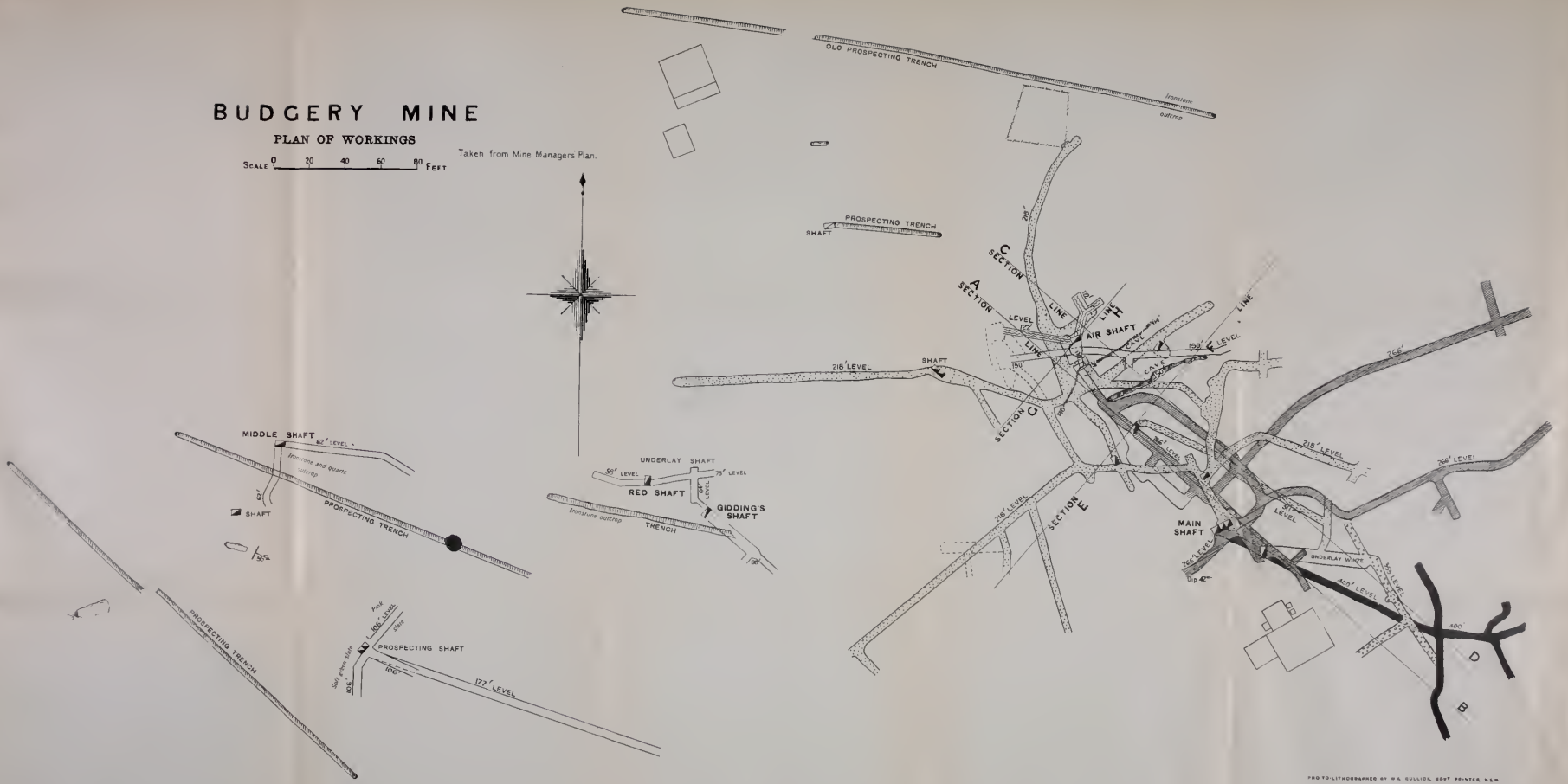


PHOTO-LITHOGRAPHED BY W.A. GULLICK, GOVT PRINTER N.S.W.

R Y M

40 60 80

ne Manager's Plan.

NW

C TION G H

f copper

NE

H

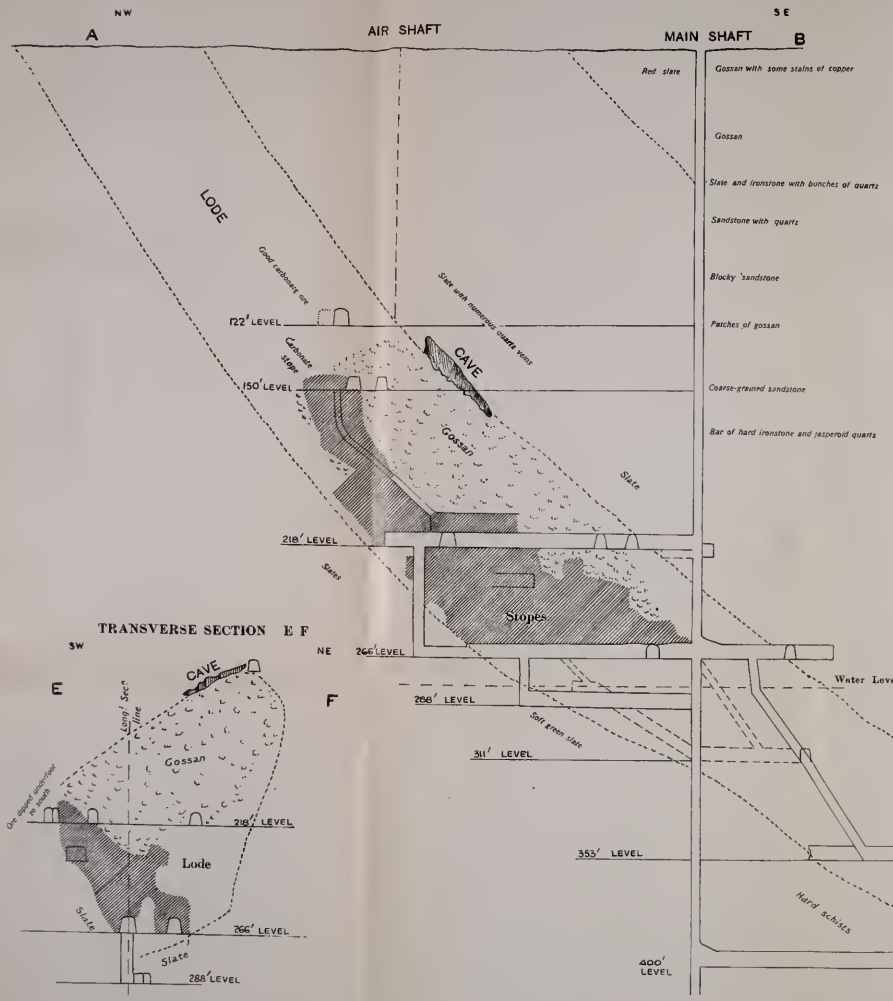
nches of quartz

BUDGERY MINE

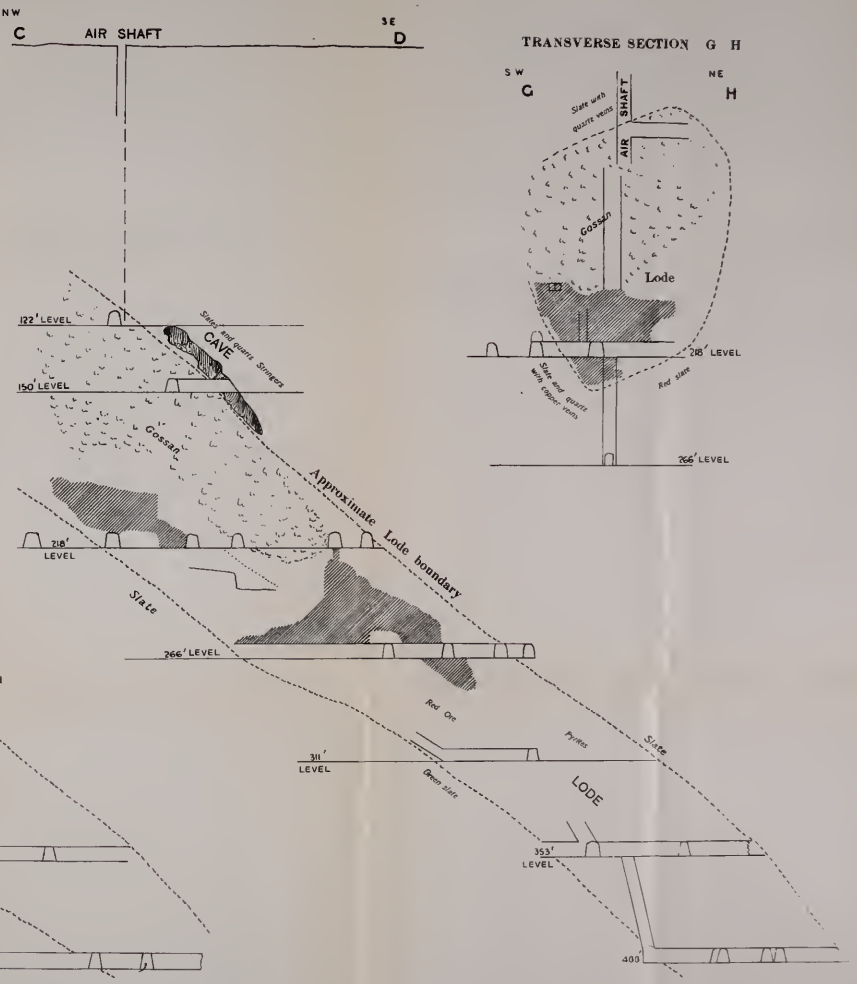
SCALE 0 20 40 60 80 FEET

Taken from Mine Manager's Plan.

LONGITUDINAL SECTION A B



LONGITUDINAL SECTION C D



TRANSVERSE SECTION E F

TRANSVERSE SECTION G H

PHOTO-LITHOGRAPHED BY W.A. GULLICK, GOVT PRINTER, N.S.W.

ing by at least one-half in a few feet. The ore was mostly disposed of to the Great Cobar, Limited, at Lithgow, some little difficulty being encountered owing to excess of magnesia in the gangue.

"Several applications failed to obtain an official statement of output to end of 1907. . . . .

"As showing depreciation at lower levels, in August, 1907, it was announced in the press that 23 tons 16 cwt. 1 qr. 5 lb. at the Great Cobar Works, Lithgow, yielded 5·86 per cent. As the latter grade could not be disposed of at a profit owing to cost of carriage, active mining practically ceased on exhaustion of the available richer ore, and efforts were confined to sinking a new shaft. The nature of the ore so far proved is likely to render direct smelting difficult.

"As stated elsewhere, great excitement followed the discovery of Budgery . . . . and numerous companies floated, every possible variation of the original name being used as an inducement for investment."

This ore deposit was one which presented difficulties to the prospector. An examination of the accompanying plans and sections of the mine workings will suffice to make this point clear. The general form of the deposit is that of a "pipe," with a fairly steep pitch to the S.S.E. Signs of faulting action are apparent on the footwall side of the deposit, while the deposit itself appears to be a body of replacement either at the intersection of faults or of large joints. The method adopted in the replacement is strikingly similar to that to be observed in similar schistose rocks farther to the north, as at Budgerygar, namely, by conversion of certain contorted beading planes to ore and pyrites while other parallel beds do not appear to have been affected to anything like the same extent by the wandering solutions. As in the Budgerygar and Bonnie Dundee Mines, replacement of the slates and allied rocks was incomplete, the crystals of sulphide ore being set in a matrix of country. The ore deposit, as worked, appears to be of secondary origin, the upper portion of the body being a barren gossan, which at points lower down gave place, in part, to carbonates of copper, chalcocite (copper glance), native copper, and cuprite (red copper oxide). The richer masses were found on the footwall side of the pipe-like mass. All these points are admirably illustrated in the accompanying maps supplied by the management. At the 400-feet level pyrites, with small patches of secondary chalcopyrite (yellow copper ore) were found, the average tenor in value of the ore being low. The prospects of finding pay-ore in quantity below this level are not at all bright. The deposit was worked in the earlier days by following the ore, then at a later date a vertical shaft was sunk from which drives were put out at short intervals for the purpose of prospecting and working the pipe-like mass. Levels were formed in this way at depths of 122, 218, 266, 266, 311, 352, and 400 feet respectively from the surface measured along the underlay.

The following note on the Budgery Mine has been supplied under date 30th January, 1914, by Mr. J. R. Godfrey, a former manager of the mine, and now a Government inspector of mines:—

"The ore-body at the 218-feet level in the Budgery mine at Hermidale occurs between two heads or faults, one striking N.E. and dipping S.E. about 45°, the other striking N.N.W., and dipping E.S.E. about 60°, thus forming a trough in which the richer ore was deposited. The higher grade ore extended upwards for about 30 feet above the 218-feet

level, and then merged into a large body of practically valueless gossan, while at the 250-feet level it had passed into the purely sulphide zone, consisting of an irregular body of iron pyrites carrying copper values averaging 3½ per cent.

"On the footwall side of the above faults no quantity of ore of any value was found, while on the hanging-wall side the values rapidly decreased when driving away from the faults, and gradually died out in the country rock without any sign of a break or head or wall; thus indicating that the ore body was due to impregnation and infiltration from the trough outwards.

"The axis of the trough gradually turned more to the south at the deeper levels and became flatter, but I am not acquainted with the later history of the developments of this mine.

"Practically the whole of the marketable ore was obtained between the 180 and 260 levels, some of it assaying as high as 63 per cent. copper.

"The highest bulk parcel sent away during my management assayed about 14 per cent. copper. The shipments generally averaged about 8 per cent., on which value profits could be made until the price of copper fell below £70."

In addition to the preparation of the valuable maps here reproduced, Mr. A. L. V. Brain, a former manager of the mine, has also furnished interesting details, from time to time, concerning the ore-deposit itself in the various annual reports issued by the Budgery Copper-mining Company. A few of these details are reproduced in this brief description of the Budgery, because the upper levels are now almost inaccessible.

"*266-feet Level.*—The width of ore mined has varied from 6 to 30 feet. The ore varies in quality from 3½ to 9 per cent. copper, 11 to 25 per cent. iron, and 27 to 61 per cent. silica. The better portions occur through the ore formation in irregular bands and bunches. On the northern end of the formation only is there a defined head, or wall, to mark the limit of the ore; on the western side a head, or series of heads, give a somewhat irregular limit to the ore; and on the eastern side, the ore gradually becomes poorer, breaks up into bands, and merges into country. The southern limit of the ore has not yet, in my opinion, been definitely ascertained at any level."—Directors' Report, 1910.

"*122-feet Level.*—An examination of the air shaft showed promising patches of carbonate ore, and trial bores revealed better prospects. A drive was started at 122-feet level in a northerly direction. At first this work gave considerable promise, but the ore died away into threads, or gave way to siliceous gossan, with traces of copper.

"*218-feet Level.*—Opening out from the main shaft, and following a small vein of grey ore mixed with red iron veins and slate, a drive to the north-west 22 feet from the shaft struck the southern end of the ore formation, then passing a few feet of good ore merged into gossan as the drive was extended to 40 feet. A run of mixed carbonates and gossan, value about 5½ per cent. copper, was followed to the west until connected to the No. 2 south drive to form a mainway for working the ore above the 218-feet level. At 25 feet from main shaft a north-east drive has been put in 36 feet through red iron bands carrying copper, which gradually fell in value from 5 to 2½ per cent. Off this drive a

drive to the north for 20 feet marks the division between the gossan and red iron bands, and along the junction mixed carbonate and black ore gives an average of about 5½ per cent. copper.

"*266-feet Level.*—The north-east drive started on the northern wall has been extended a further 24 feet, met some bunches of prill ore, the main body being low grade. On the west side of main level a winze was sunk 17 feet. The ore became mullocky and reduced in value within a few feet of the level. South of the main shaft 48 feet, a drive in a north-easterly direction was put in on slate carrying 3 per cent. native copper for 12 feet, when it became poor. This apparently marks the southern limit of the ore at this level.

"*288-feet Level.*—Drive extended 25 feet in a southerly direction in ore formation about 3½ per cent. copper.

"*311-feet Level.*—From the underlay winze a drive has been put in a northerly direction for 27 feet, mostly iron pyrites, assaying about 2 per cent. copper. At 15 feet from the winze a north-west drive was extended 40 feet, and then struck the north wall. The ore in this drive became gradually more oxidised. . . . . .

"*353-feet Level.*—The ore formation does not differ very materially from the lower level.

"*400-feet Level.*— . . . . . A drive put in on north side of main crosscut, attempting to follow the better-assaying portions of the ore, made an erratic course of 22 feet, and finished in a mixture of slate, iron pyrites, and quartz, with traces of copper.

"Bulk sample from this level assayed as follows:—

Copper	1·25 per cent.
Iron	29·82 „
Sulphur	24·57 „
Silica (abs.)	20·01 „

Such portions of the ore formation as have in the various drives assayed fairly well are possibly all secondary enrichments, no body of such ore being found."—Directors' Report, 1911.

It was natural, upon the development of the Budgery ore deposit, which outcropped as a mass of limonite gossan, that other ironstone outcrops existing in the immediate vicinity of the main workings should have been prospected. Nevertheless, no ore-body of commercial value has been discovered by such prospecting. A few notes, however, descriptive of the prospecting operations are here reproduced from Mr. Brain's reports:—

"*Western Outcrops,* M.L. No. 1.—About 500 feet west of main plant several chains of costeening was done, and afterwards a prospecting shaft sunk to a depth of 180 feet, and a crosscut put in at 177-feet level for a distance of 181½ feet in an easterly direction. At 70 feet from surface an ironstone and quartz formation, 4 to 5 feet thick, was passed through underlaying to the east, below which soft contorted slates followed, carrying traces of copper, and continued till nearly the bottom of shaft. The crosscut passed through the same class of country, but more contorted, and not equal in copper. Some break or change in course has taken place, otherwise the ironstone formations passed in the shaft and showing on surface would have been cut in this crosscut.—Directors' Report, 1911.

"*Red Shaft Formation.*—Gidding's shaft. A new shaft sunk vertically for 60 feet, connected by a short drive to workings from old Red shaft; then continued on the underlay, following down a very promising gossan formation to a total depth of 96 feet. The gossan cut out at this depth, and below no trace of wall or indication of continuation could be found.

"*Prospecting Shaft* (western section, M.L. 1).—The shaft was opened at 107-feet level, and crosscuts put in to cut the quartz and gossan formation passed through at about 70 feet in the sinking. The country was very favourable, and in parts the slate contained up to 1 per cent. copper; one small quartz leader for about 20 feet long gave very promising prospects of gold. No continuation of the formation in the shaft could be traced.

"*Main Shaft* (eastern formation) 266-feet level.—The pyrites formation 120 feet north-east of the main ore formation has been further crosscut 39 feet, and driven on north-west and south-east 32 feet. Traces of copper were met right through, and some small veins, from which assays were obtained from 2 to 3 per cent. copper. . . . . .

"*Main Ore Formation,* 266-feet level.—A prospecting drive has been extended to a total distance of 55 feet in a north-easterly direction from the main shaft, through pyrites formation, with about 2 per cent. copper, with veins and patches of ore up to over 6 per cent. copper. This shows, like the 218-feet level, a tendency for the ore formation to continue further east than previously thought."—Directors' Report, 1912.

THE BUDGERYGAR MINES.

The Budgerygar.

M.L. 5, parish Tritton, county Canbelego. The first mention of this mine in the official records is by Mr. J. E. Carne, an extract of which is herewith supplied:—*

"Strong gossany outcrop in schist country. The lode strikes N. 7° W., and underlays easterly, and consists of an impregnation highly pyritised, which at surface forms strong irony outcrop.

"In the vertical shaft the impregnated belt was cut at 20 feet, and passed through at 147 feet. From the 203-feet level a crosscut reached the footwall boundary of the mass in 62 feet, and was continued across it diagonally for 46 feet without reaching hanging-wall boundary. From this point a winze was down 45 feet (in October, 1907), where at bottom nearly pure iron pyrites was making.

"The crosscut at 203-feet level in the impregnated zone passed through thin veins and finely-disseminated pyrites—more or less black or sooty in parts owing to alteration of the little copper sulphide present—into subsulphide. Across the full thickness of this enriched mass a sample was carefully taken, which yielded the following results:—

"No. 07-7540—

Gold	...	a trace.
Silver	...	3 dwt. 6 gr. per ton.
Copper	...	0·30 per cent. ,,

* "Copper-mining Industry," 1908, p. 195.

PLAN OF BUDGERYGAR AND BONNIE DUNDEE MINES

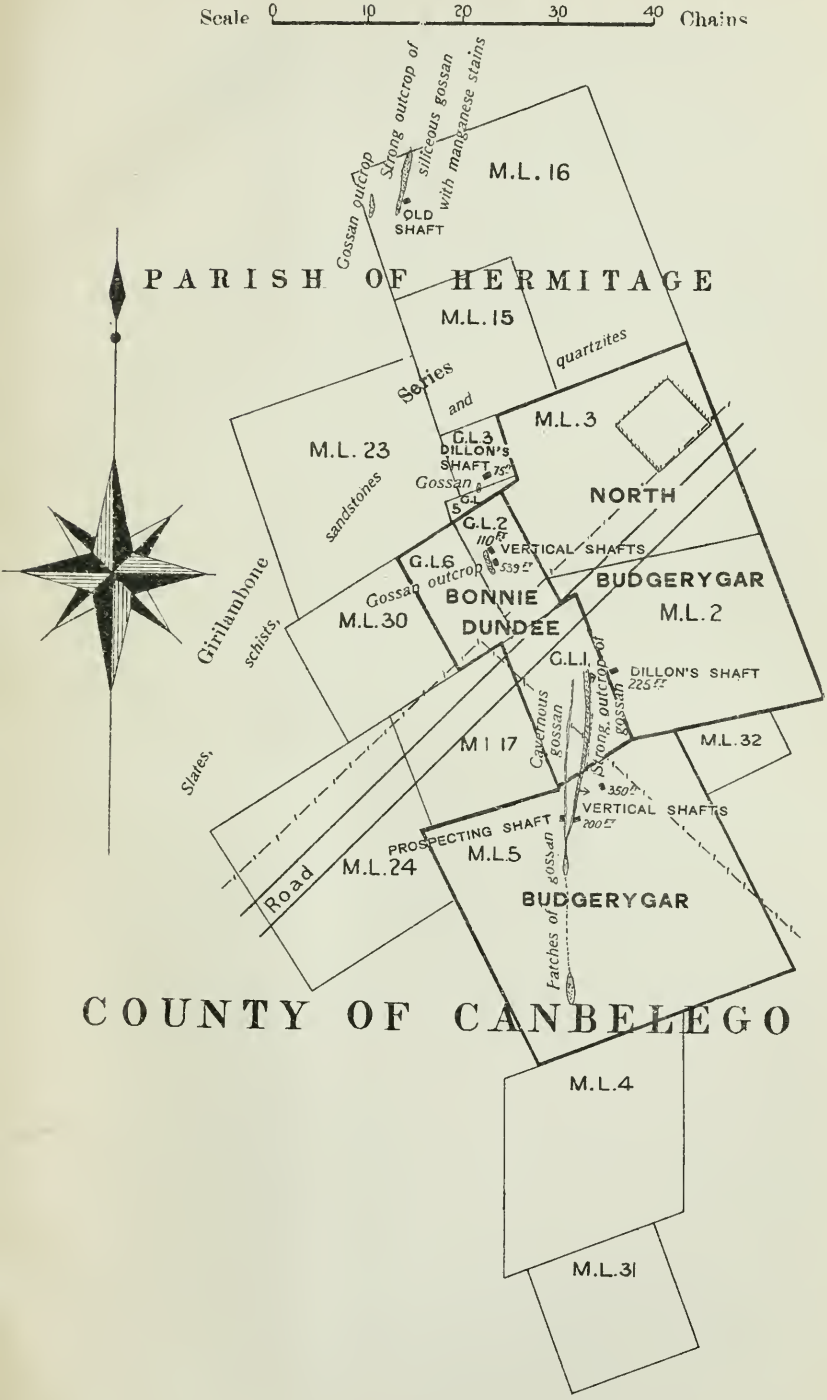


PHOTO-LITHOGRAPHED BY W. A. GULLICK, GOVERNMENT PRINTER, SYDNEY, N.S.W.

"A sample of the unaltered sulphides chipped across the full width at bottom of winze yielded:—

"No. 07-7539—

Copper	none detected.
Gold	a trace.
Silver	,,

"In June, 1908, more promising developments were reported in a new shaft, 270 feet deep, and a drive of 25 feet from the level." . . .

A long gossan outcrop traverses both M.Ls. 5 and 2, and this is worked respectively by the Budgerygar and Budgerygar North companies. The lodes dip east, and the main shafts of both companies have been sunk so as to intersect the lodes—that is, they are situated to the east of the outcrops. Between the main shafts the outcrops are continuous, consisting of strong ironstone gossans, possessing a subparellel disposition. Immediately to the south of the Budgerygar shafts, however, the more western outcrop appears to junction with the main member, as indicated on the accompanying plan. In each case the gossan is seen to be slightly cavernous, by reason of the removal of the small cubes of iron pyrites, which form a portion of the lode.

The country consists of slate and sandy slate much crumpled and altered, with a strong belt of altered sandstone lying at a short distance to the east.

The eastern lode, as exposed in the Budgerygar workings, is very wide, and has a general dip to the east; nevertheless, it exhibits marked irregularity of detail in form. The thin beds of sediment composing the geological structures of this locality have been intensely crumpled and puckered, and certain of the beds have been converted into ore deposits, while parallel beds show but slight traces of alteration. The replacement of the beds was incomplete, as the pyritic beds, seemingly solid at first glance, are in reality altered country thickly studded with cubes of iron pyrites with copper pyrites. In this connection the reader is referred to the appended analyses of samples secured from the mine by Mr. Carne. Plates XXXVIII and XXXIX illustrate well the peculiar action of replacement in the formation of these lodes. Fig. 8 illustrates a detail of lode structure, as seen between the timbers in one of the vertical shafts; while Fig. 9 is an ideal of the eastern lode, based upon notes made in the long eastern crosscut, at a depth of 350 feet from the surface. The hanging-wall in places appears to consist of a thick mass of ironstone, which might be expected to yield commercial results, as in the neighbouring Budgerygar North. The western body is not revealed in the workings, and probably has not been intersected by the shafts.

The gossan outcrops south of the Budgerygar shafts are discontinuous, one large patch occurring near the south end of M.L. 5, and on the line of the main eastern body. This point is illustrated on the map.

The following notes on the workings are based partly upon personal examination and partly upon information supplied by Mr. E. E. Tyler:—

The eastern ore body has been prospected by two shafts, one of which is 200, and the other 350 feet, in depth.

Old Shaft Workings.—This, the earlier prospecting opening, is 200 feet in depth, and is of the nature of a three-way whip-shaft. To the east a crosscut has been put in for a distance of 68 feet to the footwall of a "streaky" formation. This "streaky" formation, to adopt a term employed by the mining community, is, in reality, the incomplete replacement of parallel beds of sediment, the dark layers of replacement contrasting strongly with the

alternate lighter rays of country, which has not undergone replacement by sulphide ores. The crosscut has been put in for a distance of about 63 feet into what is supposed to be the hanging-wall of the formation. At this point a winze has been sunk connecting with the 251-feet level from the main shaft, a short distance to the north. A crosscut has been put in also for a distance of 12 feet to the west of the bottom of the shaft, making a total length of 155 feet for the cross-cutting, allowing a length of 12 feet for the shaft.

The Main Shaft is 350 feet in depth, and is only a two-way opening for a depth of 250 feet. Thence to the 350-feet level it possesses three compartments. It is vertical throughout. At the 250-feet level a drive has been put in to the south for 160 feet, in a so-called "kaolin" formation, consisting of decomposed country. This drive connects the workings from the old shaft by way of the winze already mentioned. A drive has been put in north from the main shaft for a distance of 64 feet, making a total of 224 feet of driving directly from the shaft at this depth. From the shaft, also, a crosscut was put in to the east for a distance of 30 feet in the "kaolin." Thence the crosscut was continued for 20 feet in a gossan.

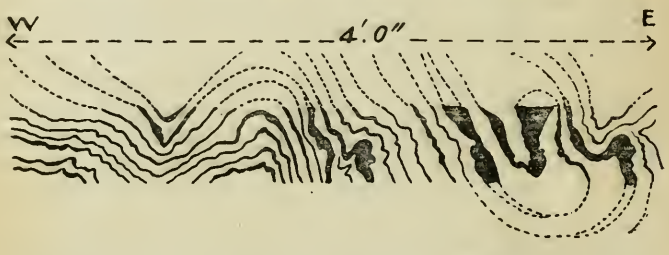


Fig. 8.—Detail of Budgerygar Lode, as sketched between timbers in vertical shaft.
Shaded areas represent imperfect replacement of folded sediments by pyrites.

From the base of the shaft, about 350 feet below the surface, a crosscut had been put in for a distance of 186 feet, in July, 1913. The crosscut passed through contorted slates and allied rocks for a distance of 120 feet from the shaft. At this point the footwall of the "streaky" formation was intersected, and the crosscut penetrated this formation of country and sulphides (Figs. 8 and 9) for a distance of nearly 70 feet. Fourteen feet along the crosscut from the footwall a drive has been put in on the lode for a distance of 162 feet to the north. A considerable amount of work has been carried out at a later date in the matter of extending the crosscut and the northern drive. This work is justified, in view of the fact that the gossan outcrop to the north is very strong, and that the Budgerygar North has been working a rich patch of secondary copper ore from what appears to be the northern portion of the same ore body, and that at a point of the lode at which the outcrop was not very prominent.

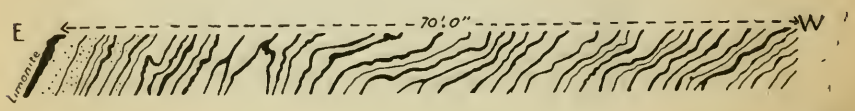
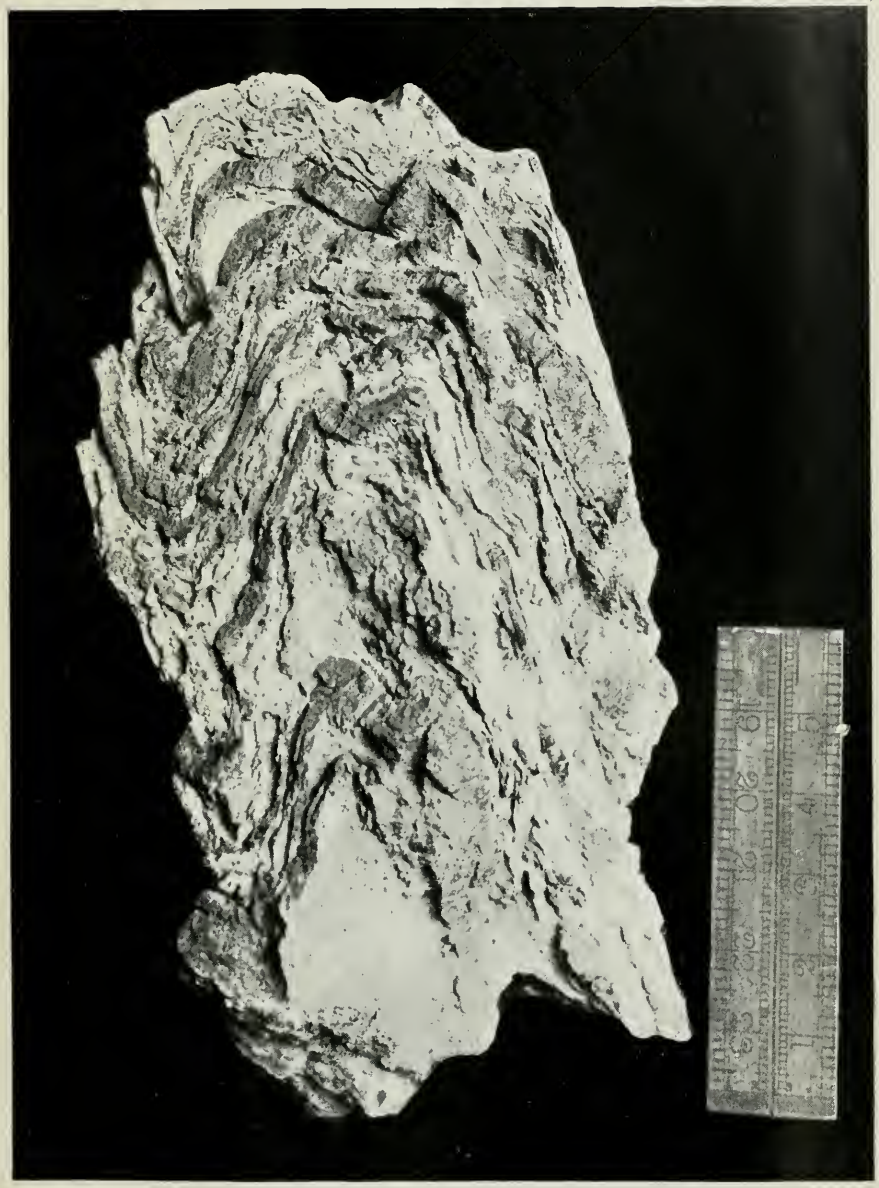


Fig. 9.—Sketch section, Budgerygar Lode, showing replacement of folded sediments by pyrites.



Budgerygar Ore, illustrating variable action of replacement of sedimentary beds by sulphide ores. Shaded bands represent sulphide replacements.

Budgerygar Ore, showing variable action of replacement of sedimentary beds by sulphide ores. Shaded bands represent sulphide replacements.

It has been thought that the sulphides of the Budgerygar and the Bonnie Dundee deposits would act as fluxes for ores of a more siliceous nature, such as those of Girilambone. With this idea in view, Mr. J. E. Carne secured several samples of the ore for purposes of assay. The following results indicate that the workings at the time did not possess a basic ore. On the other hand, the ore as mined at present from the Budgerygar North appears to be decidedly basic in nature, and it is possible that these ore deposits, if opened up between the present shafts of the Budgerygar and Budgerygar North, lying about 800 feet apart, would yield patches of ore of a basic quality. In this connection, however, it must be remembered that the ore being despatched from the Budgerygar North is of secondary nature, and the nature of the primary ore therefore can only be inferred.

Prospecting operations were carried on during 1913 along the lower levels, but no payable ore was sent away.

Results from samples taken by Mr. J. E. Carne from old workings of Budgerygar Mine:—

"Sample No. 1, 1787.—Seventeen feet width in the crosscut east from the shaft, 275-feet level. About 3 feet in width of orey lodestuff behind this on the footwall side; this dies away in pyritic country.

1787—

Gold	a few grains per ton.
Silver	3 dwt. 6 gr. ,,
Copper	1·90 per cent.
Silica	23·16 ,,
Iron	21·56 ,,
Sulphur	25·12 ,,
Magnesia...	less than 0·50 per cent.

Sample No. 2, 1788.—Thirty-seven feet width at east end of crosscut at 350-feet level from north drive.

1788—

Gold	a few grains per ton.
Silver	3 dwt. 6 gr. ,,
Copper	0·80 per cent.
Silica	33·28 ,,
Iron	21·84 ,,
Sulphur	22·46 ,,
Magnesia...	less than 0·25 per cent.

Sample No. 3, 1789.—Fifteen feet black ore, footwall side 350-feet level, from crosscut between footwall and north drive.

1789—

Gold	a few grains per ton.
Silver	3 dwt. 6 gr. ,,
Copper	0·70 per cent.
Silica	25·66 ,,
Iron	20·30 ,,
Sulphur	23·93 ,,
Magnesia...	less than 0·50 per cent.

Sample No. 4, 1790.—From face of north drive in black ore at 350 feet depth.

1790—

Gold	a few grains per ton.
Silver	2 dwt. 17 gr. ,,
Copper	1·40 per cent.
Silica	34·32 ,,
Iron	17·08 ,,
Sulphur	20·08 ,,
Magnesia...	less than 0·50 per cent.

The Budgerygar North (Block No. 2).

M.L. 2, parish Tritton, county Canbelego.—The first official mention of this mine is in 1910.* The shaft was then down 225 feet, and the lode had been passed through at a depth of 90 feet from the surface in the shaft. It was reported to be from 3 to 9 feet in width. A parcel of 9 tons of ore was sold for £23.

In 1911, 200 tons of ore were raised, of which 166 tons were disposed of for £620. A crosscut was put in 77 feet in an easterly direction at the 160-feet level, and about 40 feet of driving was carried out 20 feet to the north and 20 feet to the south. The ore mined consisted of grey sulphide (chalcocite) and red oxide.

Mr. J. Polkinghorne, reporting on this mine, wrote:—†

> "The ore occurs in what appears to be a pipe, and underfoot the ore is narrow and short; and overhead it is very much smaller than where the crosscut intersected the body at the 160-feet level. I am inclined to the opinion that it will prove to be the same body as the shaft passed through at the 100-feet level. Sinking from the 100-feet level and raising ore from the 160-feet level will be pushed on in 1912. So far the ore body has only been proven for a distance of 30 feet."

In 1912 eight men were employed on the mine; 280 feet of cross-cutting, driving, and sinking were carried out at the 160-feet and 200-feet levels. According to Mr. Inspector Oldfield,‡ the "deposits were found to be rather irregular and small, thereby giving only a limited production. The prospects are considered to be fairly good."

Budgerygar North lies about 4 miles from Wilgar Downs and 13 miles from Hermidale, in a direction slightly west of north. The accompanying plan and section illustrate the method of working the mine and the general occurrence of the deposit. Two gossan outcrops lie to the west, one at a distance of about 150 feet from the shaft and one about 100 feet further to the west. Mr. James Dillon was the prospector who commenced operations by sinking a vertical shaft to the east of the gossan outcrops which traverse M.L. 2. At a depth of about 80 feet an ill-defined deposit was intersected, composed of limonite and containing what appeared to be hæmatite, mixed with earthy red oxide of copper, copper carbonates, and copper glance. In 1910 the body was opened up at the 100-feet level and followed thence in a south-easterly direction for a distance of about 32 feet, the pitch of the copper deposit in the lode appearing to be to the south. Further prospecting was carried out at a depth of 160 feet, and a crosscut was put out in an easterly direction for 73 feet. At this depth a body of ore was met with similar in many respects to that found at 100 feet depth. A parcel of about 140 tons is stated to have been sent from this level to Great Cobar for a return of about 10 per cent. copper with a little gold and silver. Red oxide and copper glance comprised the ores from this section. The walls of the deposit of this level did not appear to be well defined, slate and sandstone composing the greater portion of the country. The shaft is now 225 feet deep, and the lode has been followed from the 160-feet level almost continuously down to the lowest level. The deposit appears to be replacement of country by iron and copper sulphides in part, but the primary ore has not been reached as yet, neither has water-level been found. Difficulties both have been, and even yet are, encountered in following the

* Annual Report, 1910, p. 46. † Annual eport, 1911, p. 90. ‡ Annual Report, 1912, p. 94.

NORTH BUDGERYGAR MINE

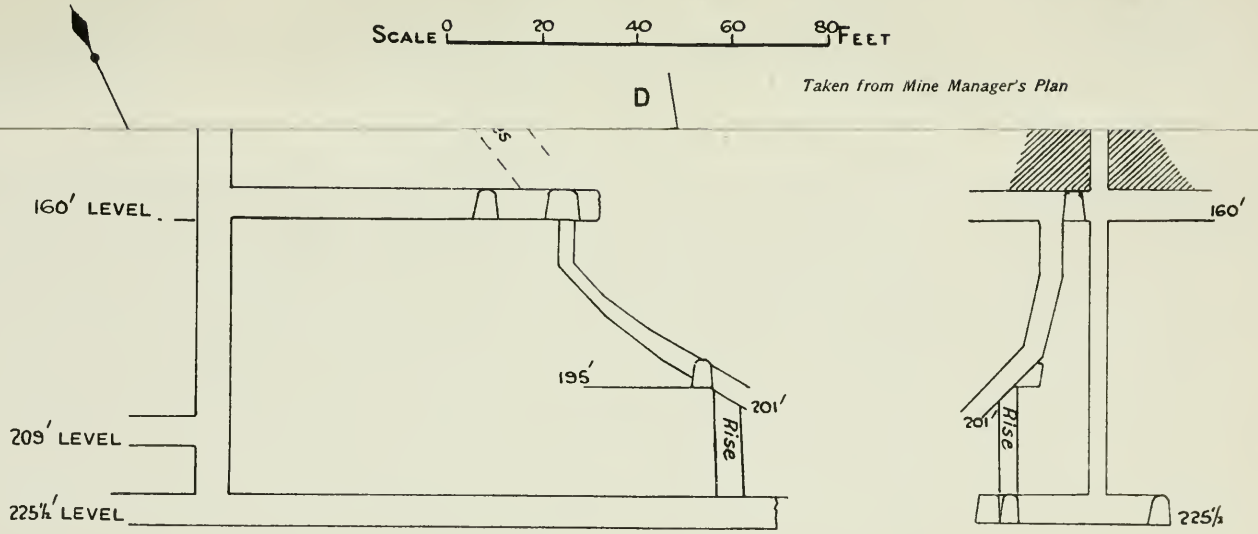
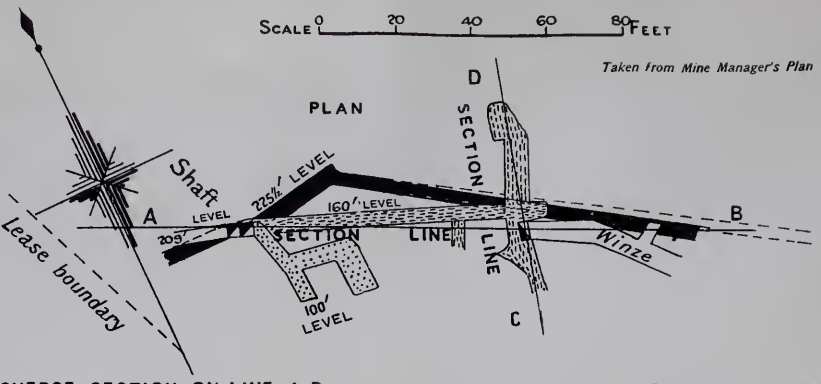
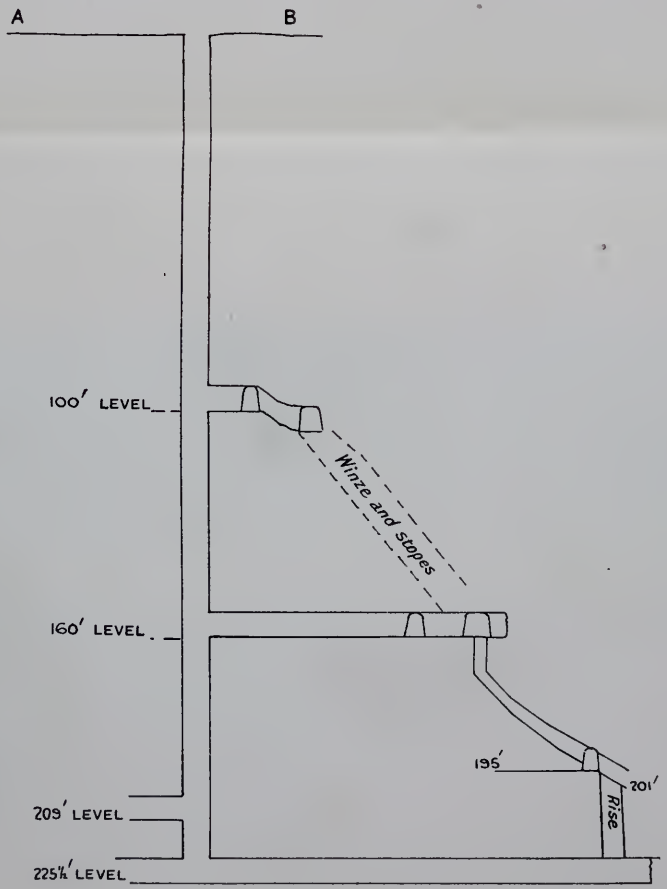


PHOTO-LITHOGRAPHED BY W. A. GULLICK, GOVERNMENT PRINTER, SYDNEY, N.S.W.

NORTH BUDGERYGAR MINE



TRANSVERSE SECTION ON LINE A.B.



LONGITUDINAL SECTION ON LINE C.D.

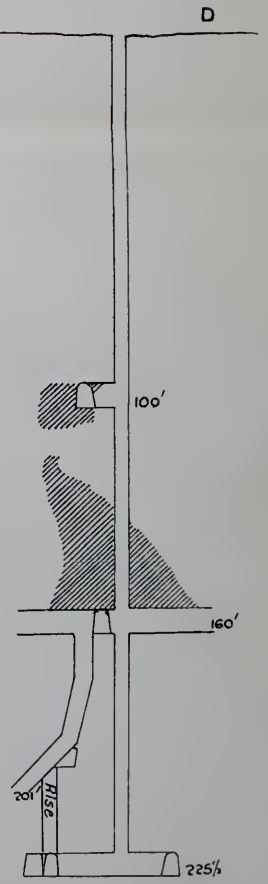


PHOTO-LITHOGRAPHED BY W. A. GULLICK, GOVERNMENT PRINTER, SYDNEY, N.S.W.

deposit, owing to the excessive contortion and puckering to which the country has been subjected and to the fact that the replacement bodies conform to these contortions and puckerings of the country. Thus, at a depth of about 200 feet, a trough or basin of ore of considerable size was encountered. The occurrence gave considerable trouble to the prospectors. It is however an expectable consequence of the replacement of beds of closely-folded country, whereby portions of the deposits may be expected to occur in the form of saddles, inverted saddles, basins, domes, and steep or flat dipping masses. In all such cases the only safe rule is to follow the ore until the general disposition of the occurrence is known. The case of the peculiar disposition of the ore-body in the Mount Boppy lode at the intermediate level may be cited as an example of the difficulties attendant on prospecting these irregularities in the ore-body (caused by the occupation of contorted sediments by ore-bearing solutions). In this case the only method that could be adopted safely was to follow the irregularities of the ore-deposit, as its course could not be foretold except in a general way. In the same way the ore-deposit of the Budgerygar North may be said to have a general inclination to the east, nevertheless there are many local deviations from that general inclination.

From the account sales furnished to this Department at the close of 1911 by the company, 156 tons of ore appear to have been produced, averaging about 12½ per cent. copper and containing an average excess of 14 units iron over silica.

Since the note on this mine was written, the following information has been supplied by Mr. Inspector T. S. Oldfield in his report for 1913 to the Chief Inspector of Mines:—

> "This mine has worked on and off during the year, raising 297 tons of ore for a value of £1,261. . . . The ore was chiefly obtained from 160-feet winze, where the ore-body appears to have rolled considerably and become disturbed. . . . Owing to the Great Cobar being unable to take the ore, this company has been forced temporarily to close down. . . .
>
> "The prospects of this mine are considered to be good."

The Bonnie Dundee Syndicate.

G.Ls. 1, 2, and 6, and M.L. 17, parish Tritton, county Canbelego.

History.—"The Bonnie Dundee Syndicate, Canbelego, sank the No. 2 shaft 210 feet, and carried out 50 feet of cross-cutting. They employed on an average seven men. The shaft passed through some very nice seams of ore of high-grade copper contents, but, owing to insufficient capital, work was suspended at the end of the year in order to raise additional funds."*

During the following year four men were employed on the mine, and the shaft was sunk to a depth of 306 feet, and a level was driven for a length of 50 feet.

In 1909 the prospects of the Bonnie Dundee were encouraging, and in 1910 further prospecting work was carried out and the shaft was sunk to a depth of 498 feet from the surface. "No. 4 crosscut was driven 56 feet, and

* Annual Report, 1907.

a drive put in 70 feet north and 130 feet south. From this drive, and from a rise 23 feet above that level, 600 tons of ore were raised and sold to the Great Cobar, Limited, containing 16 tons of copper, 41 oz. of gold, and 427 oz. of silver, having a gross value of £1,058. . . . The cutting of the lode at the 500-feet level, at which depth it is intended to open out, will be of great interest. The ore at a depth of 400 feet is very basic, assaying up to 42 per cent. iron and 11 per cent. silica, the average copper-contents being just 3 per cent."*

In 1911, the mine, by this time known as the Bonnie Dundee Copper and Gold Mine, was practically shut down in October, two men only being kept on to sink a winze below the No. 1 level. The shaft was sunk a further depth of 20 feet, and at a depth of 500 feet a crosscut was driven south-east for 100 feet, "crosscut driven east off north drive at the 400-feet level 12 feet, and the raise above 400-feet level risen 7 feet. The winze below No. 1 level was sunk 28 feet from the back of No. 4 level driving of No. 5. Two hundred and forty tons of ore were raised and sold to Great Cobar, Limited, the average assay value being 3 per cent. copper, 1¼ dwt. gold, and 3½ dwt. silver. The result of sending the ore to Great Cobar, Limited, has shown that this mine, with a furnace on the ground, would more than pay working expenses, but does not pay to send the ore away. A basic ore-body was proven at the 400 and 500 feet levels, averaging about 5 feet wide, carrying about 35 per cent. iron, 40 per cent. sulphur, 13 per cent. insoluble, and 4 per cent. copper, evidencing a good pyritic smelting body. Without a plant on the mine the ore-bodies cannot be worked at a profit. At the 300-feet level a large body of oxidised ore was opened up, and from there to the surface a large quantity of ore could be mined to blend with the basic body in the lower levels. There is also a fair body of siliceous ore at the lower levels."†

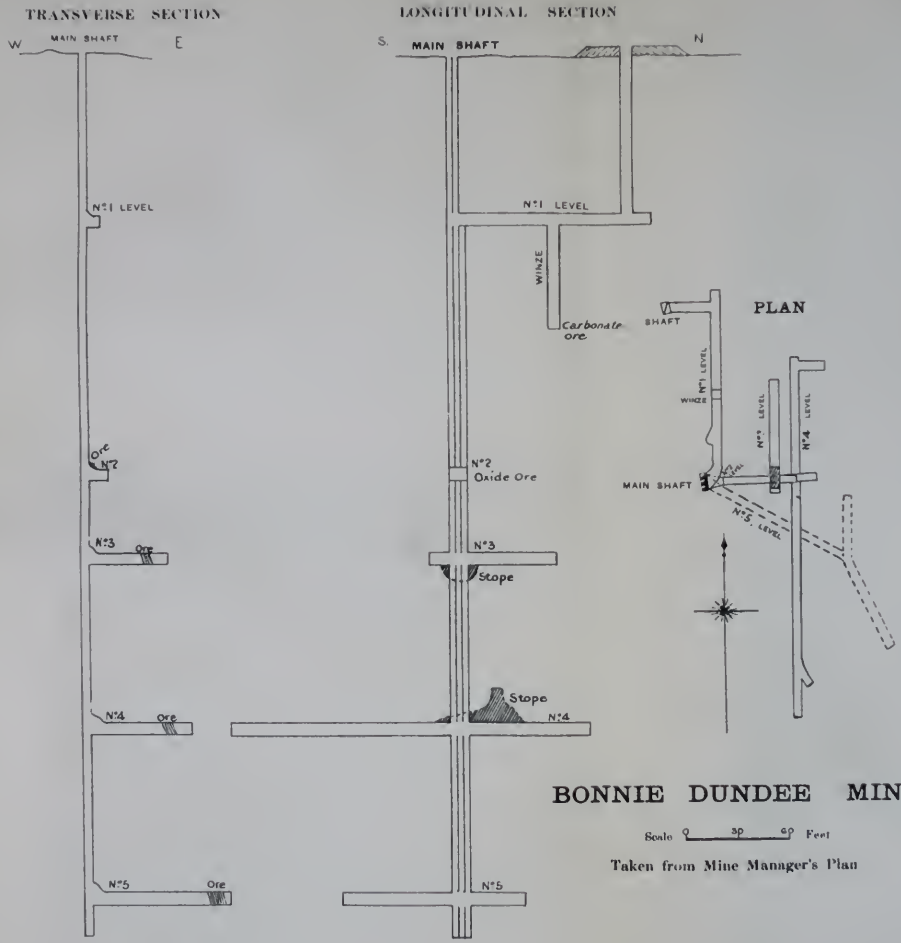
In 1912, Mr. Inspector Oldfield reported‡ that little else had been done on this mine besides sinking a winze 75 feet on the 100-feet level north. In the winze carbonate stains of copper were found, but no payable ore-body. Work was discontinued during 1913.

The mine workings were not accessible during the visit of the writer in 1913, and the accompanying notes are based upon an examination both of the surface and the spoil heaps, and upon information also supplied by Messrs. E. E. Tyler and J. H. Dillon. Additional notes are also supplied from observations made by Mr. J. E. Carne and Mr. J. Polkinghorne.

The strike of the lode is almost north and south, and the main shaft is about 1,100 feet from the Budgerygar North. The outcrop of the lode was small and of the nature of an ironstone gossan, while the dip is to the east. Crumpled and altered slates and sandy slates from the country, while a powerful belt of metamorphosed sandstone lies to the east and at a moderate distance from the lode. The material composing the spoil-heaps furnish evidence of the action of replacement of the country along certain bedding places to the exclusion of others. A peculiar feature also in this connection is the imperfect nature of the replacement. At first glance the ore appears to be a mass of solid pyrites containing copper, but upon closer inspection it may be observed to consist of a base, or matrix of country, thickly studded with crystals of iron pyrites. This feature explains the low percentages of

* Annual Report, 1910, p. 97. † J. Polkinghorne, Annual Report, 1911, p. 90.
‡ Annual Report, 1912, p. 94.


TRANSV
W
MAIN ST


TRANSVERSE SECTION
W
MAIN SHAFT
E
N°1 LEVEL
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Ore
N°4
Ore
N°5
Ore
LONGITUDINAL SECTION
S.
MAIN SHAFT
N
N°1 LEVEL
WINZE
Carbonate ore
N°2
Oxide Ore
N°3
Stope
Stope
N°4
N°5
PLAN
SHAFT
N°1 LEVEL
WINZE
N°2 LEVEL
N°4 LEVEL
MAIN SHAFT
N°5 LEVEL
BONNIE DUNDEE MINE
Scale
30
60
Feet
Taken from Mine Manager's Plan

iron and sulphur returned from the samples taken by Mr. Carne and referred to in a later paragraph. The copper contents are reported to have been found first at a depth of about 250 feet, while gold contents occurred above this level. Water level lies about 320 feet below the surface.

The following notes on the workings have been adopted, in part, and in part extracted from a report made to the directors in July, 1912, by Mr. J. Polkinghorne, formerly Government Inspector of Mines:—

The main shaft has been sunk 520 feet. Previous prospecting had been carried out by a shaft 110 feet in depth and about 2 chains north of the deeper shaft. Crosscuts from this earlier shaft had been put in to test the leases at depths respectively of 45, 80, and 110 feet from the surface. From these more superficial workings gold had been won. At the 110-feet level a crosscut put in 30 feet to the east had proved a lode 6 feet in width while a drive had proved the existence of the lode for 100 feet to the south. A winze 26 feet in depth was sunk on the lode at a distance of 60 feet along the drive from the shaft. At this point, according to Mr. Polkinghorne, the first trace of copper was found, the ground having been prospected previously for gold.

> "The main shaft was then sunk and connected with the drive from the prospecting shaft. At 218 feet in the main shaft carbonates of copper were met. At 238 feet high-grade grey copper ore was met. . . . At this point the lode underlies to the east of the shaft. At 300 feet a crosscut was driven east about 50 feet, the east wall of lode being struck at about 43 feet. A drive was then driven north, starting on the east wall of the lode, which was proven by crosscut to be upwards of 30 feet wide, the value of lode on east side being 5 per cent. copper, 3 dwt. of gold, and 3 oz. of silver. The face of the north drive, 50 feet from crosscut, assayed 3½ per cent. copper, 2½ dwt. gold, and 3 oz. silver, the lode being at this point greatly oxidised."

At the 400-feet level, Mr. Polkinghorne pointed out that a crosscut had been put in 57 feet to the eastern wall of the lode, the latter being 23 feet wide in the crosscut, while the lode for a width of 8 feet upon its eastern side contained an increased content of iron and sulphur. Drives were put in north and south of the crosscut for a total length exceeding 200 feet, the average value of the copper being recorded as 3½ per cent.

"At the 500-feet level the crosscut was driven about 23 degrees south of east and not at right angles to the lode, so that this crosscut reached 103 feet before cutting the east wall at that angle; the crosscut was in lode matter over 30 feet. Had the crosscut been driven east the lode should have been crossed in 65 feet of driving. The north drive at this level was taken into the east wall and not along the strike of the lode. The south drive was put in along the more pyritic portion of the ore-body, which averaged 4 feet in width, and is said to have assayed 4½ per cent. copper, 2 dwt. gold, and 2 oz. silver.

The work done has proven the lode, to a depth of 500 feet, to be a strong fissure between two good walls, the underlie being about 15 feet in each 100 feet of depth.

The mine is equipped with a good winding engine capable of hauling cages and trucks containing 15 cwt. of ore from a depth of 1,000 feet. The shaft is substantially and securely timbered and divided into three compartments with a good head gear, cages, and bailing tank. The water is not heavy and does not exceed 3,000 gallons per twenty-four hours."

Mr. J. E. Carne, Assistant Government Geologist, examined the mine in June, 1909, and secured two representative samples from a depth of about 200 feet. The results are attached:—

Sample No. 1, 1793.—From crosscut 13 feet long in ore-body, 200-feet level.

Gold	1 dwt. 15 gr. per ton.
Silver	15 dwt. 19 gr. ,,
Copper...	1·10 per cent.
Silica	35·44 ,,
Iron	15·68 ,,
Sulphur	18·54 ,,
Magnesia	less than 0·5 per cent

Sample No. 2, 1794.—From drive 45 feet along lode, 200-feet level.

Gold	a few grains per ton.
Silver	16 dwt. 8 gr. ,,
Copper...	1 70 per cent.
Silica	32·00 ,,
Iron	18·20 ,,
Sulphur	16·17 ,,
Magnesia	5·34 ,,

The lower levels were inaccessible during the visit of the writer in 1913; but, according to the statements of Messrs. Tyler and Dillon, the copper and iron contents of these lower levels are considerably higher than is shown for the upper levels by the samples secured by Mr. Carne. In this connection also the extracts from the report of Mr. Polkinghorne are of interest.

The general relations, in space, of the Bonnie Dundee, the Budgerygar, and the Budgerygar North are shown on the accompanying plan of the subject leases and mines.

Appendix.

Messrs. Negus and Polkinghorne showed me a crinkling or corrugation of the northern portion of the Mount Boppy Lode along the Nos. 4 and 5 levels, indicating thereby that the lode had a greater length than had been estimated previously. As a result of such discovery, attention was directed to the lode along Nos. 2 and 3 levels, and it was ascertained that additional quantities of ore to those previously estimated existed there also. It is highly probable, also, that a similar irregularity exists in the lode at depths greater than 600 feet. The lode is thus opening up at certain positions in a manner which promises better than was anticipated.

Exploration, meanwhile, is being carried on steadily below the No. 7 level.

1914.—The Mount Boppy Gold-mining Company crushed 70,059 tons of ore during 1914. The tailings treated were 12,762 tons, and the slimes 53,020 tons. From this material 30,393 oz. gold were won, valued at £128,793. The total amount of ore treated from the mine since 1900 has been 761,390 tons, which has yielded 331,265 oz. gold, valued at £1,406,920.

The accompanying notes, dealing with the work done at the mine during 1914, have been extracted from the General Manager's annual report:—

"A diamond drill, installed at the 700-foot level, has proved that a formation, strong in character, and consisting of quartz and quartzite, and having a width of 70 feet, exists at that depth. . . . .

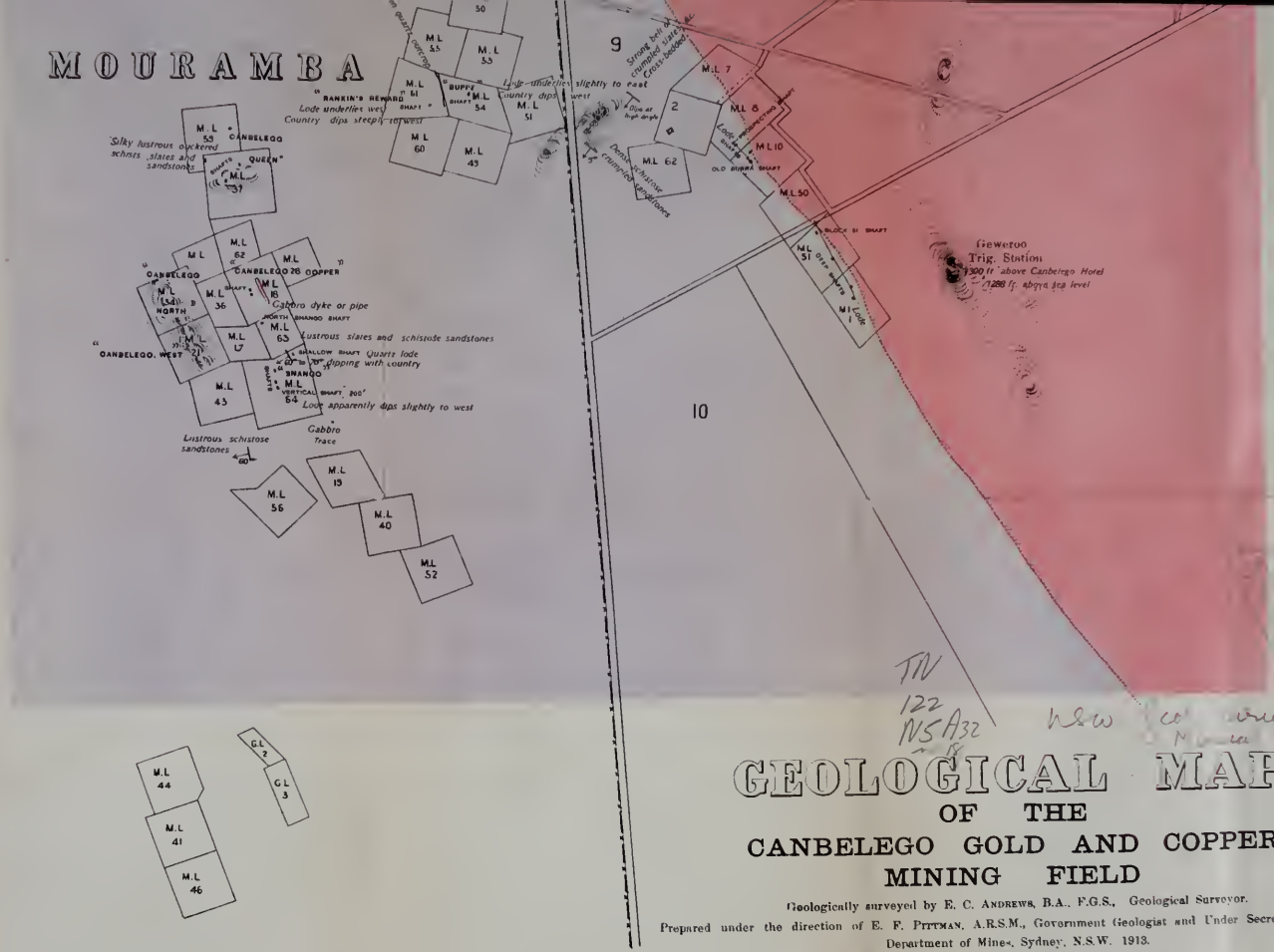
"The favourable lateral developments along the western leg have been affording proof that the future of the mine is not so dependent now, as in the past, on discoveries in depth. The western extensions and explorations, which have added so materially to the ore reserves in the past two or three years, continue to carry ore in portions of the mine hitherto considered unprofitable, and have produced approximately about 70,000 tons of ore per annum during the past four or five years. . . . . It is intended to give special attention to the folds and twists of the western leg portion of the ore body. . . . . It has been observed, in the year under review, that the footwall continues strong and well defined, but the western side of the ore body shows evidence that the crushing which has taken place has formed channels for the solutions which entered the slates. Numerous small rich veins have in this way been formed, and stoping operations have been profitably conducted to widths varying from 10 to 40 feet in sections which had, in the early developments of the mine, apparently ore of a width of only 5 or 10 feet."

In 1912, the recovery of gold amounted to 71·5 per cent., whereas in 1914, after the new plant had been employed for some time, the percentage of extraction amounted to 84·77 per cent. This showed a saving of 4,822 oz. gold upon the old recovery, "equal to a money value of £20,493. This is equal to a saving of 5s. 10·2d. per ton of ore treated. . . . . The treatment costs, including milling, grinding, and cyanidation, in the year 1912 amounted to 10s. 5·11d. per ton of ore treated. In the year 1914 it was 8s. 10·38d., equal to a saving of 1s. 6·73d., which, added to the saving by improved extraction of 5s. 10·20d., brings the total saving by the erection of the new plant to 7s. 4·93d., or 85·2 per cent. better than the promised improvement."

Budgerygar Mine.—Mr. E. E. Tyler reports the discovery of a large body of pyritic ore to the east of the shaft. In developing this find, 224 tons of ore are stated to have been won, of an average content of from 5 to 7 per cent. of copper. The dimensions of the body of ore have not been ascertained as yet.

Sydney: William Applegate Gullick, Government Printer.—1915.

BOPPY MTN
RAILY STN
Argillaceous and slaty sandstones
RAILWAY
FLORIDA
RAILY STN
Old trenching shaft
E
Mount Boppy
1330ft
above sea level
Subangular outwash
Shaft in red schistose slates
FLORIDA
SECTION LINE
See Sketch Map
B
COUNTY OF CANBELEGO
C
8
7
D
COHN
COUNTY OF
Schists showing in gully
Boppy Boulders
Boppy Blocks
Boppy outcrop
Lava Ridge
Conglomerates
Schist
Strong outcrops of conglomerates
Outcrops of coarse schists
Schists and sandstone
ROBINSON
Cold leases
NORTH MOUNT BOPPY
MOUNT BOPPY
VILLAGE OF CANBELEGO
SEE PLAN TO ENLARGED SCALE
Small patch of schist covered mostly by Devonian rocks
SOUTH MOUNT BOPPY
W.L.118
W.L.117
Fine schistose slates
THE PRIEST'S SHAFT
CANBELEGO PEAK SHAFT
Strong outcrops of schistose sandstone
Porphyry dyke of pipe
Silver lead
Shaft
MOURAMBA SHAFT
Devonian conglomerates and tuffs
COUNTY OF
FLINDERS
GEWEROO
6
3
COUNTY OF
BUPPE
MOURAMBA
M.L 20
M.L 50
M.L 55
Strong barren quartz outcrops
9
Well marked flow structure
See Map of Boppy Broken Hill Mines



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GEOLOGICAL MAP
OF THE
CANBELEGO GOLD AND COPPER MINING FIELD

Geologically surveyed by E. C. ANDREWS, B.A., F.G.S., Geological Surveyor.

Prepared under the direction of E. F. PITTMAN, A.R.S.M., Government Geologist and Under Secretary for Mines.

Department of Mines, Sydney, N.S.W. 1913.

Scale 0 20 40 60 80 Chains

REFERENCE

RECENT		*Alluvium.* Shown only at Canbelego.
DEVONIAN		Boppy Series. *Sandstones, conglomerates, and quartzites*
SILURIAN		Ballast Series. *Radiolarian cherts, claystones, and sandstones*
PRE-SILURIAN(?)		Canbelego Series. *Slates, schists, sandstones, and quartzites*
IGNEOUS		*Quartz-Felspar Porphyry with tuffs*

PHOTO-LITHOGRAPHED BY W. A. GULLICK, GOVERNMENT PRINTER, SYDNEY, N.S.W.

GEOLOGICAL MAP
OF
CANBELEGO

Geologically surveyed by E. C. Andrews, B.A., F.G.S., Geological Surveyor.
Prepared under the direction of E. F. Pittman, A.R.S.M.,
Government Geologist and Under Secretary for Mines,
Department of Mines, Sydney, N.S.W., 1913.

Scale 0 5 10 15 20 Chains

REFERENCE

RECENT	*Alluvium*
DEVONIAN	Boppy Series — *Sandstones quartzites and conglomerates*
PRE-SILURIAN (?)	Canbelego Series — *Slates, schists, sandstones and quartzites*
IGNEOUS	*Quartz–Felspar porphyry*

COUNTY OF CANBELEGO

COUNTY OF ROBINSON

VILLAGE OF CANBELEGO

PARISH OF FLORIDA

C.L. 1, 2, 3, 4, 5, 6, 7, 8, 9, 10, 11, 12, 13, 14, 15, 16, 17, 18, 19, 20, 21, 22, 23, 24, 25, 26, 27, 28, 29, 30, 31, 32, 33, 34, 35, 36, 37, 38, 39, 40, 41, 42, 43, 44, 45, 46, 47, 48, 49, 50, 51, 52, 53, 54, 55, 56, 57, 58, 59, 60, 61, 62, 63, 64, 65, 66, 67, 68, 69, 70, 71, 72, 73, 74, 75, 76, 77, 78, 79, 80, 81, 82, 83, 84, 85, 86, 87, 88, 89, 90, 91, 92, 93, 94

75 Freehold

BOPPY STREET

CORONGA STREET

BUDDA STREET

MULGA STREET

CURRAWONG STREET

WILGA STREET

YARREN STREET

EDWARD STREET

WOMBOIN STREET

MOUNT BOPPY G.M. CO. LTD.

MOUNT BOPPY G.M. CO. LTD.

SHAFT No. 2 CROSS-CUT AT 200 FT. LEVEL

SHAFT No. 1 CROSS-CUT AT 300 FT. LEVEL

CROSS-CUT AT 300 FT. LEVEL

MAIN SHAFT

SOUTH SHAFT

PROSPECTING SHAFT

HENRY SHAFT

Open Cut

Mount Boppy Lode

Auriferous Lode

HIDDEN TREASURE MINE

CROSS-CUT AT 200 FT. LEVEL

SHAFT EAST MOUNT BOPPY MINE

Cross Cut 100 ft. Level

Reid and Rankin

John Warn

Hogans Block

T. Reid

KING

PHOTO-LITHOGRAPHED BY W. A. GULLICK, GOVERNMENT PRINTER, SYDNEY, N.S.W.

New South Wales
Geological
Mineral Resources
No. 18

GEOLOGICAL SKETCH MAP

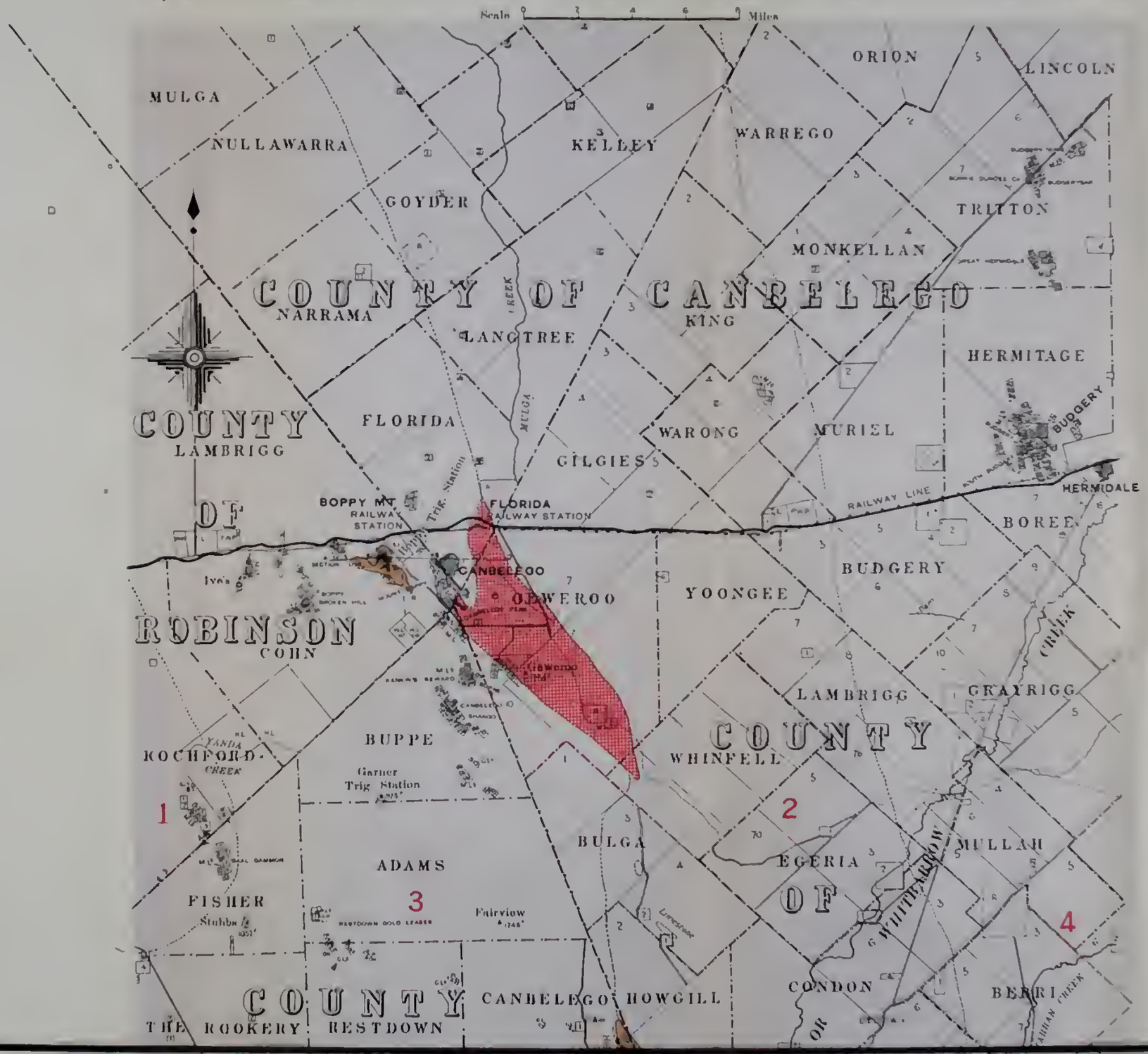
OF THE

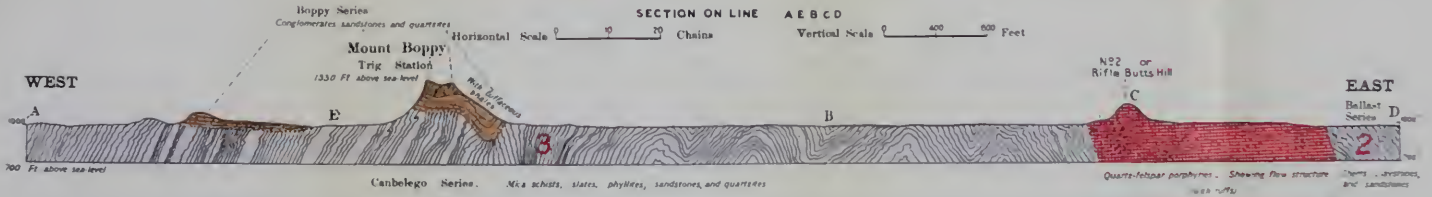
CANBELEGO — NYMAGEE

MINING DISTRICT

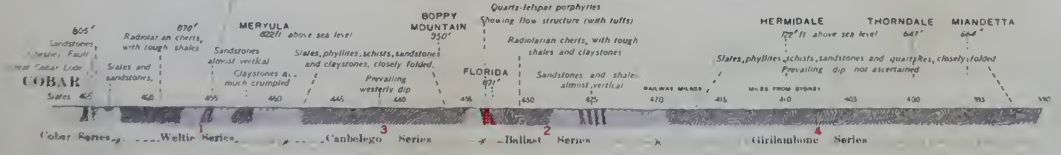
Geologically surveyed by E. C. Andrews, B.A., F.G.S. Geological Surveyor.

Prepared under the direction of E. F. Pittman, A.R.S.M., Government Geologist and Under Secretary for Mines, Department of Mines, Sydney, N.S.W., 1913





Sketch section along Railway line from Cobar to Mindetta showing apparent repetition of the Weltie and Canbelego Series.
Based upon information derived from studies of railway cuttings and infrequent outcrops.



REFERENCE

SEDIMENTARY

DEVONIAN — Sandstones, conglomerates and quartzites with tuffs & cross beds.

SILURIAN — 1 Weltie Series. Radiolarian cherts, clay stones and sandstones.

Dz — 2 Ballast Series. Radiolarian cherts, clay stones and sandstones.

Dc — Limestone

PRE-SILURIAN (?) — Cobar Series. Meta-sediments and conglomerates, cross-bedded sandstones, and slates.

Dc — 3 Canbelego Series 4 Girilambone Series. Slates, phyllites, schists, cross-bedded sandstones and quartzites.

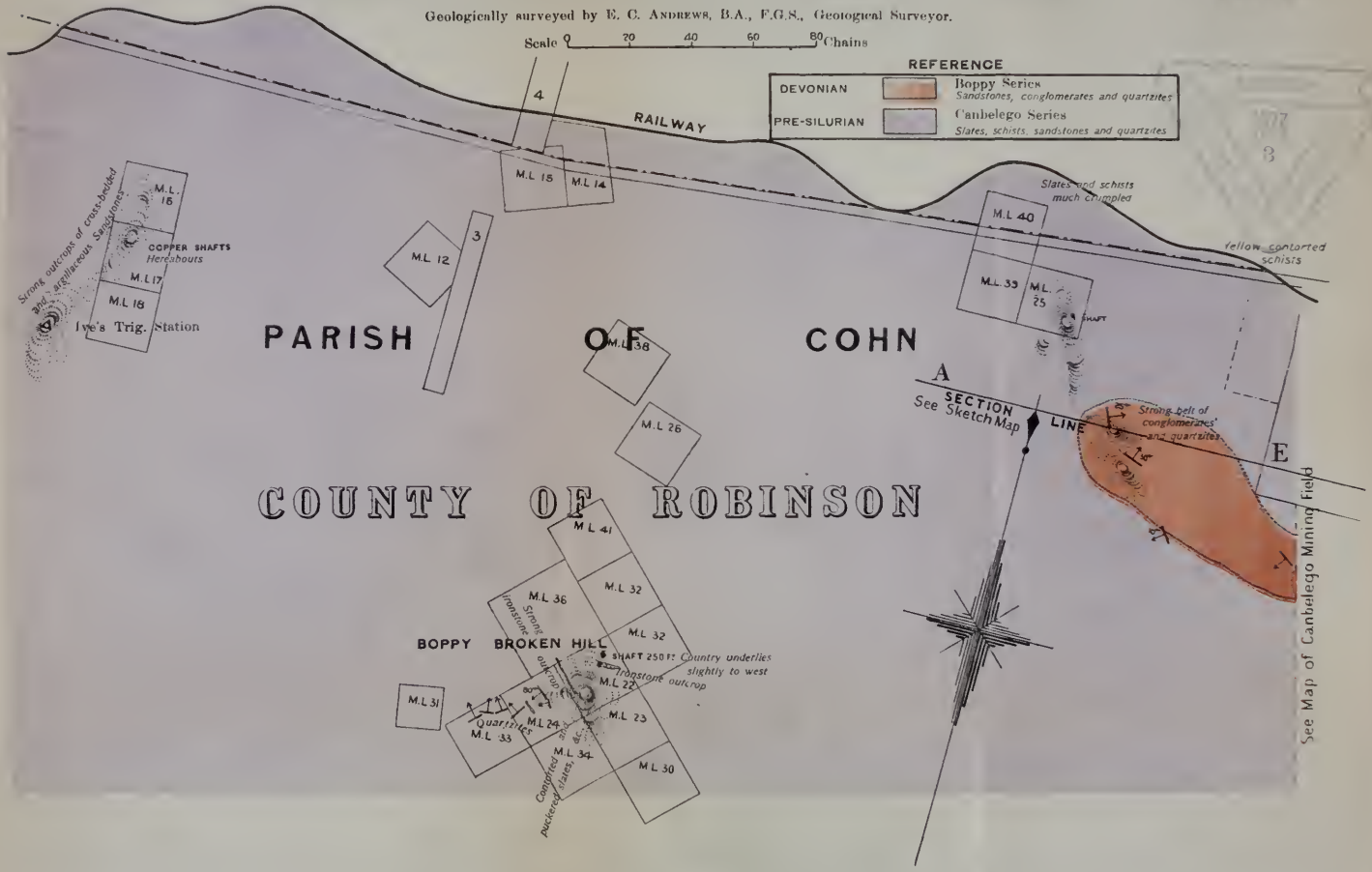
IGNEOUS — Quartz-felspar porphyries, with tuffs.

Granite

GEOLOGICAL MAP

SHEWING BOPPY BROKEN HILL, &c., MINES

Geologically surveyed by E. C. Andrews, B.A., F.G.S., Geological Surveyor.



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